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CONTENTS.

PAGE

The Transvaal: Its Mineral Resources. By PROF. J. LOGAN LOBLEY, F.G.S. (*Illustrated*) (*Map*) 49
Waves.—III. The Force of Sea Waves. By VAUGHAN CORNISH, M.Sc. (*Illustrated*) 52
Our Fur Producers.—II. Sable, Mink, Ermine, and Raccoons. By R. LYDEKKER, B.A.Cantab., F.R.S. (*Illustrated*) 55
Photograph of the "Crab" Nebula, Messier 1 Tauri By ISAAC ROBERTS, D.Sc., F.R.S. (*Plate*) 58
Another Dark Star. By Miss A. M. CLERKE 59
Photography of Invisible Objects. By J. J. STEWART, B.A.Cantab. B.Sc.Lond. (*Illustrated*) 61
Letters:—G. F. CHAMBERS, F.R.A.S.; IVO F. H. CARR-GREGG; I. G. OUSELEY; H. J. MACKINDER; HUGH ROBERT MILL 63
Notices of Books 64
Protective Resemblance in Birds. By HARRY F. WITHERBY. (*Illustrated*) (*Plate*) 66
The Limbs of Trilobites. By PHILIP LAKE, M.A., F.G.S. (*Illustrated*) 68
The Face of the Sky for March. By HERBERT SADLER, F.R.A.S. 70
Chess Column. By C. D. LOCOCK, B.A.Oxon. 71

THE TRANSVAAL: ITS MINERAL RESOURCES.

By PROF. J. LOGAN LOBLEY, F.G.S.

THE second half of the nineteenth century has been prolific in remarkable discoveries and developments, but, if for no others, it will always be a memorable epoch from the enormous additions it has given to the world's stock of gold from three continents. Its earliest years witnessed the development of the goldfields of California and Australia, then just discovered, with the sensational finding of large nuggets of gold in surface deposits; and its later years have been marked by the discovery of extraordinary auriferous rocks in South Africa.

A testimony to the African continent having for a long time been productive of gold is afforded by the name "Gold Coast," and many believe that much of King Solomon's golden store was derived from Eastern Africa, while there are undoubted remains of ancient gold workings both north and south of the Equator on the eastern side of the continent. The reputation of Africa as a gold-producing continent will, however, be chiefly based upon the recent discovery of the auriferous rocks of the South African Republic.

This portion of South Africa, commonly called the Transvaal, is an extensive region extending northwards from the Vaal River (by which it is separated from the Orange Free State) to the Limpopo River. Bechuanaland lies on the west, and the Lobombo Mountains and Portuguese possessions separate the Transvaal from the Indian Ocean on the east. Its greatest length is from the south-west to the north-east, and its eastern boundary is within forty miles from the sea at Delagoa Bay. With a very irregular boundary, the Transvaal has an extreme length and breadth of six hundred miles and five hundred miles respectively, and a total area of about one hundred and seventy thousand square miles, all lying between 22° and 29° south latitude and 25° and 33° east longitude.

In this extensive region gold has been found in many places since its discovery by Edward Button in the Klein-letaba in the year 1869. In the northern portion, between Olifant's River and the Limpopo, the widespread Zoutpansberg goldfields have been long worked, and, later, those of Lydenberg and the De Kaap Valley, in the east of the area; while, far to the west, and near the Bechuanaland frontier, there is the less important Malmani goldfield. The southern portion of the Transvaal, however, lying between the Vaal River and Pretoria, has proved by far the richest auriferous region, from the occurrence in it of rocks running east and west along which are several series of parallel outcropping beds, called "reefs," which have been found to be, speaking generally, continuously gold bearing. The elevated district containing these auriferous rocks constitutes the now world-famous Rand, or Witwatersrandt, the gold-yielding character of which was discovered in 1885; and the town of Johannesburg was founded on the Rand, at an elevation of five thousand six hundred feet above sea-level, in the following year. But besides the Witwatersrandt proper there are in this part of the Transvaal, moreover, the goldfields of Klerksdoorp to the west-south-west, Venterskroon to the south-west, near the Vaal River, and the Nigel and Heidelberg gold districts to the south-east of the Rand.

The enormously preponderating importance of the Witwatersrandt district, as well as the relative yield of gold in the other districts, may at once be seen from the following statement from the State Mining Engineer's report on the gold production of the Transvaal for the year 1894:—

Goldfields.	Gold-bearing Rock mined.	Gold. Weight.	Value.
Witwatersrandt ...	3,062,767 tons.	1,948,924 oz.	£6,714 781
Heidelberg ...	25,618 ,,	52,685 ,,	172,340
Schoomspruit ...	182,448 ,,	78,358 ,,	264,724
Malmani	387 ,,	494 ,,	1,876
De Kaap	113.963 ,,	87,483 ,,	298,598
Zoutpansberg ...	26,613 ,,	10,611 ,,	38,104
Lydenberg ...	71,568 ,,	60,276 ,,	173,275
Vryheid	5,500 ,,	—	—
Carolina	150 ,,	13 ,,	44
Pretoria	—	6	23
Totals	3,489,015 tons.	2,239,865 oz.	£7,667,152

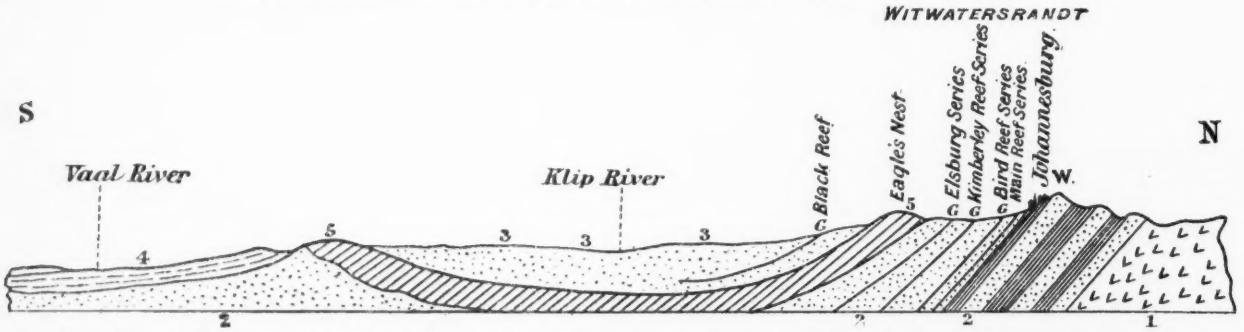
Of this great aggregate production of gold in the Transvaal for one year, only 3666 ounces, of the value of £12,806, was alluvial gold or that obtained from superficial deposits. These auriferous alluvial deposits are at Blauuwbank in the Witwatersrandt, at Barberton and Kaapsche Hoop in the De Kaap gold district, and at places in the Zoutpansberg and Lydenberg goldfields. The number of gold claims registered on the 31st December, 1894, was 3929.

The greater portion of the southern part of the Transvaal is occupied by a plateau of high land called the Hooge Veldt, or High Veldt, which extends generally east and west, but trends towards the south-west; and from these uplands flow the streams that feed the Vaal and Limpopo

Rivers, to the south and north respectively. The Witwatersrandt is, indeed, the water-parting between the two great river-basins, the northern portion of the Transvaal being formed by the slopes, with low hill ranges, from the High Veldt to the Limpopo River.

Eastwards, the High Veldt rises to greater surface altitudes, until it attains the crest of a section of the Drakensberg range of mountains, running north and south, and culminating in the Maunch Berg, seven thousand one hundred and seventy-seven feet above the level of the sea. This range descends on its eastern side with a steep escarpment—prominent along which is seen the peak of Spitz Kop—to the great De Kaap Valley, about three thousand feet above sea-level, that extends to the Lobombo Mountains, forming the eastern boundary of the State.

Section S. to N. from the Vaal Valley across the Witwatersrandt. Length of Section, 60 miles.



W. Water Parting between the Vaal and Limpopo River Basins. 5. Basalt. 4. High Veldt Beds, Coal-bearing (Karoo Beds). 3. Klip River Series. 2. Quartzite Shale Series, with G, "Banket" (Gold-bearing Conglomerates). 1. Granite.

With the exception of the De Kaap Valley, the Transvaal consists of a portion of the elevated interior land of the continent of Africa that constitutes what is called the Central African Plateau, of which the Witwatersrandt is therefore a part, and the Vaal Valley and the Limpopo northern valley are but depressions in the plateau.

The region generally is occupied by rolling grass-covered uplands, with ridges of bare rocks standing above the general surface—in some districts at frequent intervals. This rocky-surface character is given by a large amount of igneous rock in granitic bosses and dioritic and basaltic masses and dykes, together with the outcrops of the older stratified and metamorphic rocks of the country. Some of the dykes, from their position, have been subjected to less denudation than adjacent masses, and so form in places narrow ridges called "necks," which have sometimes a deep ravine on each side. The whole area is intersected by river valleys formed by the streams (torrents at times) feeding the two bounding rivers, both of which rise in the Transvaal, but flow, however, in opposite directions: the Vaal River running westwards to the great Orange River, which it joins beyond the south-west extremity of the Republic, and the Limpopo flowing eastwards towards the Indian Ocean. An important tributary of the Limpopo, called Olifant's River, traverses the interior of the area, dividing the eastern half very equally into northern and southern portions.

The Transvaal as a whole is formed by Plutonic granites and diorites, volcanic basalts and dolerites, crystalline metamorphic schists and gneisses, with unconformable but undoubtedly Palæozoic stratified rocks; and these are succeeded by a later series of rocks, again unconformable. Over large areas the outcrops of these rocks are concealed by superficial deposits of varying thickness, giving a red soil immediately below the turf. The older stratified rocks have a general southerly dip and east and west strike. The dip is usually at a very high angle, sometimes even nearly ninety degrees, but commonly from forty-five to sixty degrees, though a few miles to the south of Johannesburg and beyond Eagle's Nest the beds are nearly horizontal. It is in these rocks that the auriferous beds of the Witwatersrandt occur. The word "beds" is used here advisedly, for, although the term "reefs" is the name locally and generally given to these rocks, they are unmistakably sedimentary beds, and contemporaneous portions of the geological formation in which they are contained. They are, therefore, of an altogether different character from the well-known auriferous "reefs" of other gold regions, which are quartz veins traversing the massive rocks across their planes of original deposition. The so-called "reefs" of the Rand, on the contrary, are merely certain beds of a quite conformable series of stratified rocks, which consequently have a common dip and strike, and may, therefore, be considered to be one geological formation. It is this fact that gives to the occurrence of gold in the Transvaal an unique character, and renders it, from a geological as well as from an economic point of view, especially interesting.

The massive rocks in which the gold-bearing beds occur—the "country rock"—are for the most part hard quartzites, sandstones, and bluish shales, and the whole formation has been called the "quartzite shale series." It is altogether of enormous thickness, estimated at three miles, or sixteen thousand or seventeen thousand feet. From the absence of fossils—or at least from none having as yet been found—there is great difficulty in assigning to this great series of stratified rocks (which have been correlated with the Table Mountain Sandstone) any other than an approximate geological age; but from its general stratigraphical position with reference to the other South African rocks, and from its unconformability with overlying coal-bearing formations, it is certainly of Palæozoic and most probably of Silurian age. The whole of the rocks of South Africa may be classified as follows in descending order:—

		16. Superficial deposits.
Mesozoic.	Upper Karoo.	15. Volcanic rocks.
		14. Cave sandstone.
		13. Red beds.
		12. Molteno beds.
	Lower Karoo.	11. Karoo beds (Beaufort beds).
		10. Kimberley shales.
		Unconformability.
		9. Ecca beds.
		8. Dwyka conglomerate.
		Unconformability.

Palæozoic.	7. Quartzites.	
	6. Malmani limestone.	
	5. Bokkeveld beds (wanting in the Transvaal).	
	4. Table Mountain sandstone.*	
	Unconformability.	
	3. Malmesbury schists.	
	2. Gneiss, and	
	1. Granites.	

The auriferous beds or "reefs" are in a succession of series, each series having two, three, or more reefs, separated by the country rock of different thicknesses ranging up to one hundred and fifty feet, while the reefs themselves have thicknesses up to six or seven feet. These reefs consist of conglomerates, in which rounded pebbles of white and tinted quartz are embedded in a quartzose matrix, which, although originally sandy and loose, has been, by the infiltration of silica, rendered a very hard and compact mass. To the conglomerate the name "banket" is given. The quartz pebbles range in size from that of a pea to stones a couple of inches in diameter. It is not, however, in the pebbles that the gold occurs, but in the hardened quartzose matrix, and through this it is disseminated in small particles—so small, indeed, that it is often invisible to the eye; but this is abundantly compensated for by its generally regularly continuous and not intermittent dissemination.

Associated with the gold—which is in a metallic or "native" state, and not as an ore, or chemically combined with some other element—are the following metallic minerals: iron pyrites, with its variety, marcasite, hæmatite, ilmenite, magnetite, copper pyrites, blende, galena, and, more rarely, stibnite or antimonite, cobalt, and nickel. Of all these, iron pyrites is the most abundant. Ratile, zircon, corundum, mica, talc, and chlorite are also met with. Besides "free gold," there are extremely minute particles of gold contained in microscopical interstices of the iron pyrites, and which, accordingly, may escape amalgamation and chlorination, and even the searching cyanide of potassium, and so be lost to the miner. With improved processes and methods the amount of gold thus lost has been greatly reduced, by which much poorer material is being rendered payable than was formerly the case.

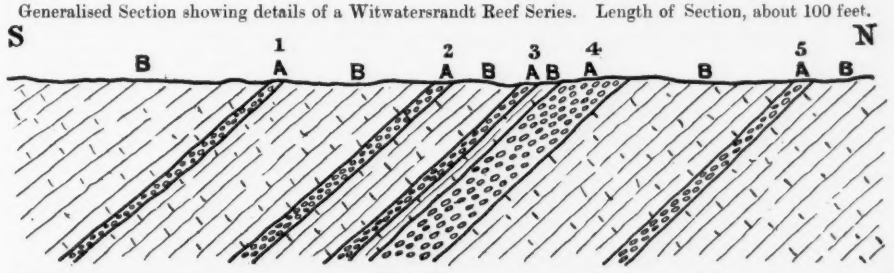
to a certain depth from the surface, or without deep shaftings, and the earlier mines were along these outcrops. It is obvious, however, that if the reefs dip from the surface at an angle of forty-five degrees—the average dip—shafts at some distance from the outcrop in the same direction as the dip, if sufficiently deep, will strike the reef, and thus there are three kinds of levels: upper, middle, and lower; but the lowermost levels as yet are only about one thousand feet deep, whereas workings at five thousand feet depth may possibly be attempted in the future.

In the older goldfields of Lydenberg and the De Kaap Valley the geological conditions are different from those of the Witwatersrandt, for the gold occurs there in thin "leaders," as they are termed, ranging from one-eighth of an inch to eight or nine inches in thickness, which cut through nearly horizontal more or less soft strata of a different geological age from that of the quartzites and conglomerate reefs of the Witwatersrandt. These leaders chiefly consist of siderite or carbonate of iron, and quartz with much oxidized iron pyrites. At Spitz Kop as many as thirty such leaders have been recorded; and sometimes these, when in fine dove-coloured argillaceous shale, become very thin, and then are unusually rich, in some cases being formed of plates of solid gold from one to ten ounces in weight. Here, too, iron pyrites is abundant, sometimes in large crystals and groups of crystals many pounds in weight.

Again, gold is reported as occurring at King's Claim in a soft breccia of sandstone, shales, etc., interpenetrated by decomposed diorite; and in Swaziland, gold associated with native bismuth is found in the heart of quartz. In the Blyde River Valley saccharoidal quartz is in parts richly auriferous, while at Kantoor "flour-gold" is disseminated not only through quartz veins, but also through their enclosing decomposed diorites.

With geological conditions such as those that obtain in the Transvaal it is evident that the total yield of gold will continuously increase with the increase of mining operations both in area and depth, until they are co-extensive with the workable auriferous beds or reefs. Thus, with the establishment of new claims and the working of deeper levels the annual output of the precious metal may be expected to show a yearly increase. What will be the

Generalised Section showing details of a Witwatersrandt Reef Series. Length of Section, about 100 feet.



A. Banket, beds of Gold-bearing Conglomerate. B. Country Rock, Quartzites and Sandstones. 1. South Reef. 2. Middle Reef. 3. Main Reef Leader. 4. Main Reef. 5. North Reef.

Although the gold is not chemically combined with any other element, it is always mechanically intimately associated with other substances, and is therefore never obtained as absolutely pure gold. The proportion of "fine gold," as perfectly pure gold is termed, is here about from eight hundred and twenty to eight hundred and fifty parts per thousand, with from one hundred and twenty to one hundred and forty parts of silver, and from thirty to forty parts of other impurities.

Since the auriferous reefs crop out they can be worked

* The gold-bearing rocks of the Witwatersrandt are assigned to this formation.

ultimate limit of that increase it is impossible to say; but Mr. Hays Hammond, whose great practical knowledge of the auriferous deposits of the Rand is so well known, says he "would regard as well within the bounds of conservatism the prediction that the annual output before the end of the present century will exceed twenty millions sterling worth of gold."

The metallic riches of the Transvaal are not confined to gold.

Silver in association with copper and lead occurs in granitic rocks in several parts of the country, as near Malmani, Pretoria, Rustenberg, and north of Middleberg.

XUM

Copper ore occurs at various places near the upper waters of the Limpopo as well as in the north-east of the State, and with galena, sulphide of lead, in veins in granite at the Albert Mine.

Lead ores are mined in the western part of the State in calcareous rocks near the source of the Groot Marico, and at Hamerkop, near Jacobsdal, on the Klein Marico.

Tin ore has been found in alluvial deposits on the Swaziland borders, and there are thin stanniferous veins in the granitic rocks; but it has not yet been discovered in paying quantities.

Zinc blende sometimes occurs associated with galena.

Iron ores, hæmatite, limonite, magnetite, and iron pyrites, are abundantly distributed in small quantities.

Mercury ore, cinnabar, occurs east of Barberton; and cobalt and nickel, as cobalt bloom, smaltine, and nickeline, to the north of Middleberg.

Of non-metallic minerals, diamonds have been obtained just within the Transvaal, near Bloemhof on the Vaal River, and near its confluence with the Makwsi River. Only small stones, however, have been found, ranging from one to five carats.

Salt occurs in beds to the north of Pretoria, and also still further north beyond Olifant's River, in the Zoutpansberg district.

Although true limestones appear to be wanting in the Transvaal, there is a calcareous sandstone that on being burnt or calcined yields lime for economic purposes; and in one locality there are caves with stalactites, resulting from the dissolving out of the calcareous matter from the rocks above.

Coal is a most valuable product of any country, but especially so when motive power for machinery is largely wanted, and there is not a continuously abundant water supply in the rivers available for mills. These are the conditions that give to the coal-bearing rocks of the Transvaal great importance.

The coal-bearing rocks here are in the lower division of the very extensive South African formation called the Karoo formation. To this division the name "Molteno Beds" has been given, but its geological age has not yet been satisfactorily determined, since the formation as a whole, and the coal-bearing rocks, as well as the coal itself, differ considerably from the Carboniferous rocks and the Coal Measures of this and other countries; and the fossils, although similar, are so few and of such a general character that they do not afford a sure ground for correlation. The strata are almost horizontal, and so overlie the older uptilted rocks unconformably—indicating, therefore, a much later age. They form, as a rule, high ground, and constitute an extensive and continuous area of the High Veldt, and also occur as patches sometimes overlying the primative granitic rocks.

The beds of coal are not continuous, as in the British coalfields, but in more or less lenticular masses, usually horizontal, but on slightly different horizons; though there are some seams now known to be continuous for miles. The thickness of the seams varies much, from a few inches upwards; at Belfast there are three beds of a total thickness of thirteen feet. Though the amount of coal in the rocks of the Transvaal is very great, the quality does not appear to be high, some of the samples giving a large percentage of ash; the Belfast coal gave about twenty per cent. of ash, but that of the Douglas Mine only eight per cent. There is also much iron pyrites in the shaly matter in the coal, rendering it a dangerous coal to stack in large quantities. It is generally very inferior to English coal, and unfitted for metallurgical purposes; but nevertheless it is sufficiently good for ordinary furnace coal for steam boilers, and this is the principal requirement of the Transvaal. Near the Vaal River, and near its confluence with the Klip River on the southern boundary, coal is worked, and also at Daggafontein and near the Witwatersrandt at Boksberg, and the Brakpan Colliery, where the output amounts to thirteen thousand tons a month.

With the addition of good building stone, furnished by its sandstones, a vast and varied store of valuable economic minerals available for the use of man is within the bounds of the South African Republic.

WAVES.—III.

THE FORCE OF SEA WAVES.

By Vaughan Cornish, M.Sc.

When wind blows over the surface of the sea the energy of the lower layers of moving air is employed in raising waves and in giving them a forward motion. The mechanism by which energy is thus imparted from wind to water is not very well understood, for only one aspect of the phenomenon can be observed, namely, the formation of the *water*-waves. Of the air-waves which, it is believed, are generated at the same time we know but little.

In deep-sea waves which have been raised by the wind, but are no longer subjected to its force, the water particle moves uniformly, under constant pressure, in a circle whose horizontal diameter lies in the direction in which the wave travels. In the upper half of the circle the motion is forwards, whilst the backward swing is on the lower level. Thus at each swing one-half of the energy of motion is transmitted forwards. In virtue of the energy so transmitted the waves continue to travel as free waves when no longer propelled by the wind, and thus spread beyond the tract which has been agitated by the storm.

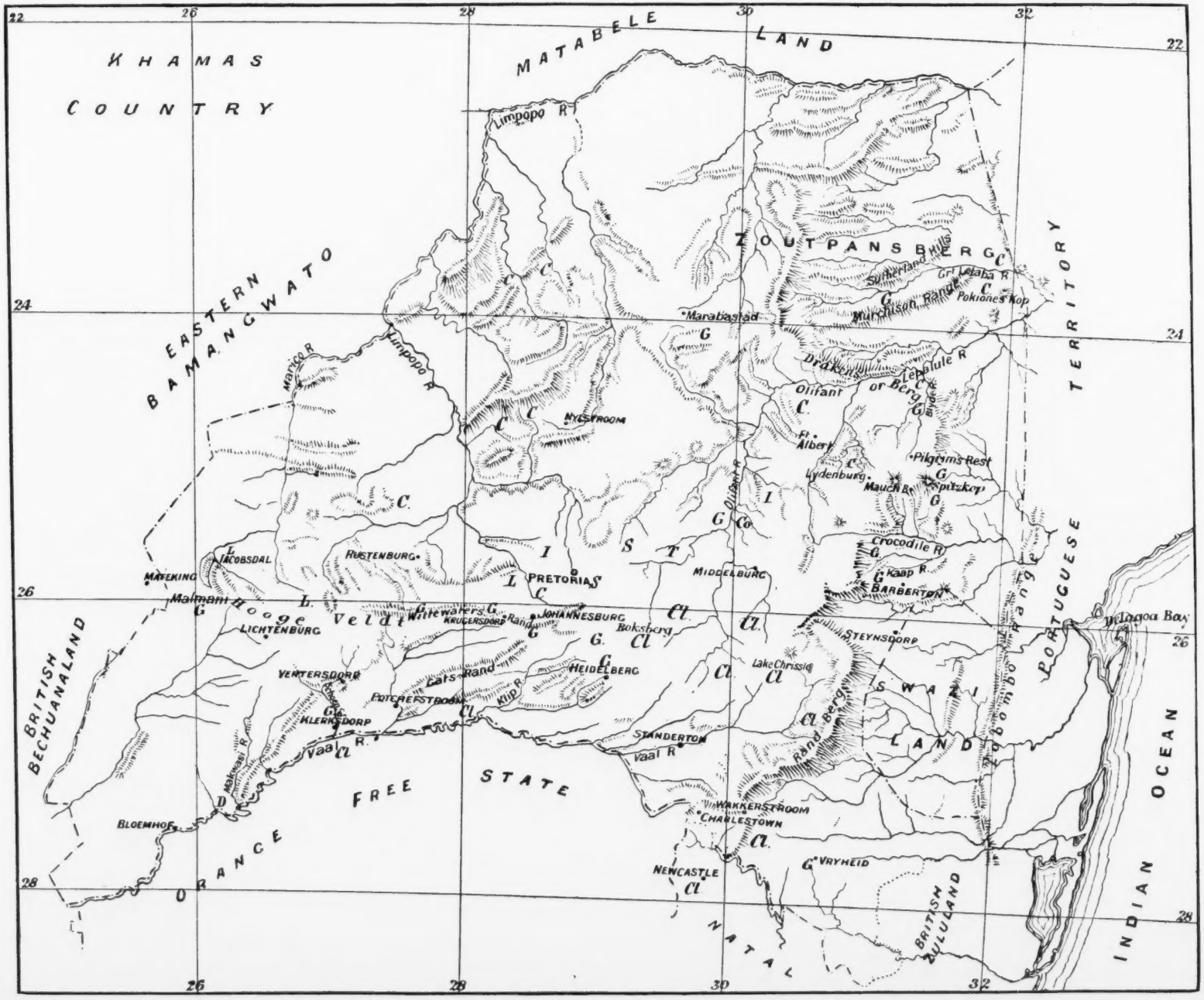
On the other hand, after each complete swing of the water one-half of the energy of motion is *retained*, so that in the original *locus* of a storm the sea continues to be agitated long after the wind has lulled; whence the persistent turbulence of the sea.

If we fix our attention upon a wave-crest of unusual height (far from the shallows of the shore) and watch the crest as it advances, we shall find that after a time it loses its pre-eminence. At first it seems as if the observer had failed in the attempt to fix his attention upon a particular crest; but repetition of the observation gives the same result. If when the crest has lost its pre-eminence the eye be turned upon the crest which follows next, it will be seen that this in its turn towers above its neighbours. This second large crest will in like manner diminish in size, and will then be followed by a larger crest. Thus the energy of the wave-motion is seen to be transmitted more slowly than the waves themselves advance. As a wave-crest passes over each point in its course it picks up and carries on half the energy of motion at that point, but the other half lags behind. For this reason it is impossible when water has the circular swing for a *solitary wave* to exist; there must always be *a group of waves*.

This may be illustrated by throwing a stone into a pond, a simple experiment from which much may be learnt. The mere displacement of water by a falling stone gives rise to a numerous group of waves, which continue to travel over the surface of the pond long after the water at the original point of disturbance has become quiescent.

On a freely undulating sea the water in its circular swing does not strike a floating body. The great rounded crest of an ocean wave, towering above the ship's bow, looks

Knowledge.


KHAMAS COUNTRY
MATABELE LAND
EASTERN BAMANGWATO
ZOUTPANSBERG
PORTUGUESE TERRITORY
BRITISH BECHUANALAND
FREE STATE
SWAZILAND
BRITISH ZULULAND
NATAL
INDIAN OCEAN
Limpopo R.
Marico R.
Crocodile R.
Vaal R.
Orange R.
Klip R.
Mooi R.
Buffalo R.
Umbogintwini R.
Umtamvuna R.
Umzimkulu R.
Umtata R.
Umtamvuna R.
Umzimkulu R.
Umtata R.
Umtamvuna R.
Umzimkulu R.
Umtata

XUM

as if it were rushing upon the ship and would presently overwhelm her; but the vessel herself is borne aloft upon the crest. On the other hand, when ocean waves are forced by violent wind, so that the tops receive a forward motion beyond that which is shared by the more protected part of the billow, the water may strike a blow upon the vessel.

Fig. 1.—Diagrams of, A, Forced Waves; B, Free Waves.

Such is the wave described by Mr. Ruskin, with "overwhelming crest—heavy as iron, fitful as flame, lashing against the sky in long cloven edge—its furrowed flanks, all ghastly clear, deep in transparent death, but all laced across with lurid nets of spume, and tearing open into meshed interstices, their churned veil of silver fury showing still the calm grey abyss below, that has no fury and no voice, but is as a grave always open, which the green sighing mounds do but hide for an instant as they pass." This passage shows a fine discrimination between the fury of the wind-forced crest and the calm of the sheltered trough. Such minute and accurate word-painting, based upon careful observation, is the literary equivalent of a mathematical formula. According to mathematicians, the highest waves driven by the strongest wind lose entirely the rounded crest; the flanks being slightly concave and meeting at a sharply-defined angle of one hundred and twenty degrees. The height of this highest possible wave is very nearly one-seventh of its length, it would travel one-fifth faster than a free wave, and the velocity of a particle when at the summit is equal to the velocity of the wave. Its form is shown in the upper curve of Fig. 1, the lower curve being a free wave, or ground swell, of the same wave-length. It was of the forced waves that Adam Lindsay Gordon wrote—

> ". . . the stoutest ship were the frailest shallop
> In your *hollow backs*."

The difference of character between the waves in the open ocean and in a closed sea is due to the fact that in the former the transmission of energy from the motion of other waves has greater opportunity to take full effect, whilst the movement of storm waves in a closed sea is more largely dominated by the immediate force of the wind. The difference has been well expressed by Victor Hugo in a comparison of the waves of the Mediterranean with those of the ocean. He writes: "Ce n'étaient pas les lames de l'océan qui vont devant elles et qui se déroulent royalement dans l'immensité; c'étaient des houles courtes, brusques, furieuses. L'océan est à son aise, il tourne autour du monde; la Méditerranée est dans un vase, et le vent la secoue, c'est ce qui lui donne cette vague haletante, bréve et trapue. Le flot se ramasse et lutte. Il a l'autant de colere que le flot de l'océan et moins d'espace."

The free wave, as we have said, does not strike upon a ship, but its heave and swing may become a source of danger by causing the ship to roll excessively. The angle through which a ship will roll, so much greater than the angle of pitching, is perhaps one cause of the common over-estimate of the steepness of wave slopes, which in the Atlantic are seldom more than seven degrees to the horizon. The momentary effort of a ship is to place her masts at right angles to the surface of the wave, but owing to inertia the vessel swings beyond this point. If the period of swing of the water harmonizes with the ship's natural period of pendulous oscillation, then at each roll to starboard the ship rolls further to the starboard, and at each roll to larboard she rolls further to the larboard side, the rolling being rapidly and dangerously increased, not by any shock of the waves, but by gravity, which the heaving sea causes to act upon the ship in a succession of well-timed pulls. Fortunately it seldom happens at sea that any considerable number of succeeding waves have the same period, the variety of independent systems of waves being thus a boon to the sailor, for the regularly increasing roll of the ship is generally interrupted before it has grown to a dangerous extent. The natural period of a ship's pendulous swing may be reckoned at about two and a quarter seconds for a vessel of ten-foot beam, and about five and a half seconds for a ship of sixty foot beam. The time of swing of the *Great Eastern* was six seconds. Remembering that the water completes one swing in the same interval of time as that between the passage of successive wave-crests past a stationary observer, and bearing in mind, also, the connection between wave-length and velocity (due to the

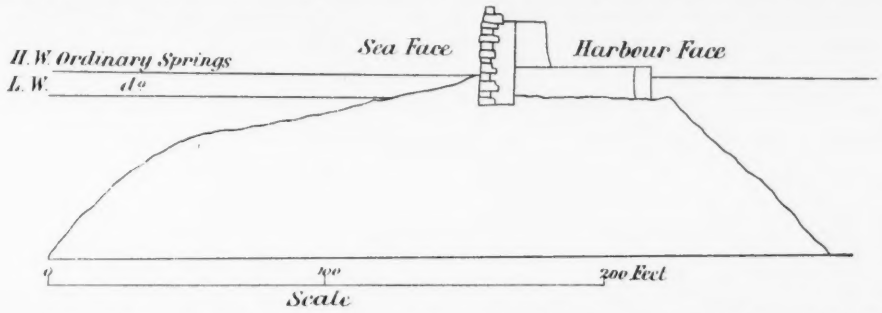
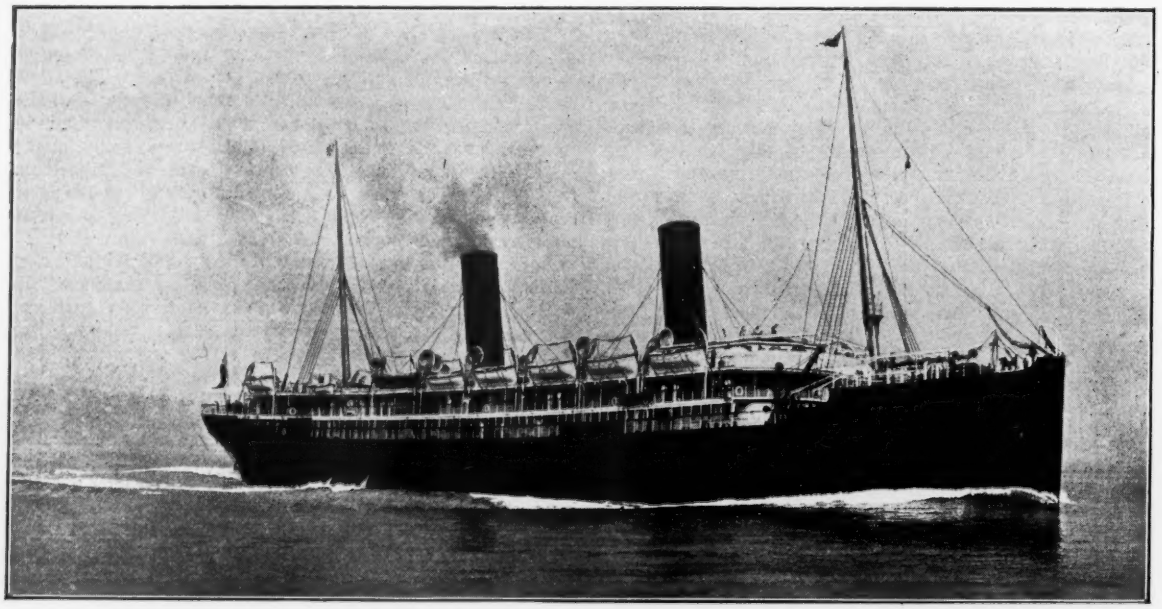


Fig. 2.—Section of Portland Breakwater, from the "Minutes of Proceedings of the Institute of Civil Engineers," Vol. XXII., 1862-3.

pendulous character of the wave), we may calculate the lengths of wave which correspond to the above periods of oscillation. A wave-length of fifty feet corresponds to a period of two and a quarter seconds, and of three hundred and ten feet to five and a half seconds. The greater the natural time of swing of a ship, the less likelihood is there of encountering waves whose period coincides with that of the ship; for it often happens that the longer waves are absent, whereas in a storm the wind is constantly forming new waves which grow in size, so that there are present at the same time waves of all sizes, and, therefore, of all periods up to the largest. A small ship is sure to meet with undulations coinciding with its time of swing, whereas a large ship may often escape.

As the billows travel onwards the energy is passed on from point to point, silently, smoothly, till the leeward shore is reached. Here all is changed. On the one side is the swinging water, ever handing on the energy of its motion. On the other side is the dead resistance of the beach, to down to the base of the cliff by these agencies is removed by the sea, so that the cliff is maintained at an angle steeper than the angle of repose, and is constantly falling. When the jointing planes of a rocky cliff slope downwards from the shore line the waves undermine the cliff, and great masses of superincumbent rock fall by their own weight, as the lumps of coal fall in a mine through the skilful undercutting of the collier.

The work of the waves is assisted not only by the flux and reflux of the tides, but also by the "heave of the sea"; that is to say, the bodily conveyance of water by wind. When wind acts upon the surface of the sea it not only carves the surface into waves, but by the exercise of a powerful tangential force, heaps up the water upon the leeward shore. Something of the kind may be observed in a roadside puddle on a squally day. When a gust of wind has passed the water springs back suddenly to windward. In wind-forced waves the motion is not precisely a completed circle or ellipse. At each swing the water particle is brought



Photograph of s.s. "Ophir," illustrating "Ship Waves."
Photograph by Adamson, Rothesay.

which each breaker as it falls yields up its store of energy. There is no finer display of natural forces than the rush of the waves on a rock-bound coast, when each billow as it nears the shore raises a steeper crest, and, dashing down in thunder on the shore, throws upwards and abroad a cloud of glittering spray which falls in salt showers upon the trembling rocks.

Everyone is familiar with the work of the breakers in tearing down cliffs and grinding the fragments into shingle and sand; but it may easily escape notice that the formation of cliffs is also the work of the sea. The space through which the breakers act is chiefly that between high and low water mark, between which a sloping shore is cut away so as to form a nearly flat beach terminated by a cliff. In point of fact the destruction and the formation of cliffs is the same process. Sometimes the waves pile up a bank of sand or shingle which protects the cliff from the direct action of the breakers. The cliff, however, gives way under the actions of wind, rain, and frost; and the material carried slightly further forward than at the end of the previous swing. The result is that a stone on the bottom tends, on the whole, to be pushed towards the shore, and this tendency increases near the line of breakers. On the other hand, the slope of the shore assists the action of the backward swing of the water, so that at a certain depth the two motions balance one another. Outside the position corresponding to this depth a sloping sea-bottom tends to move seawards. Within this line the bottom tends to move shorewards, and to pile itself up into a beach or bar. If the entrance of a harbour be on the landward side of this line the harbour is liable to be silted up, especially in a tideless sea, where there is no scour to remove the heaped-up sand and shingle.

In designing structures to resist the force of the waves the marine engineer has to take account of the length from crest to crest attained by the waves in the locality, for on this depends the depth to which the water is agitated. The time which elapses between the passage of succeeding

wave-crests, combined with the height of the waves, enables him to calculate the velocity of the swinging water particles on which depends the force he has to deal with. There has been much discussion as to the proper section which should be given to a breakwater in order that it may best resist the force of the waves. In deep water a vertical wall is presumably the most efficient. A vertical wall changes the running waves in its vicinity into *stationary waves*, in which the water simply oscillates up and down without any forward swing. This results from the reflection of the wave from the wall, the coincidence of a wave travelling towards the wall and a reflected wave travelling seawards giving rise to a wave which does not travel at all, but which retains the vertical motion, so that the position which is at one moment a crest is at the next a trough, and so on. Something of the same kind may be noticed where the sea rises and falls around a sunken rock. The stationary water-waves produced by reflection are very different from the standing waves in shallow running streams, where each crest and each trough maintains an independent fixed position. A vertical breakwater, although it has great advantages, is difficult and costly to construct; and where material is abundant and harbour space not too limited, a common method is to "dump" down a great quantity of rock, leaving the waves to lick the material into shape. This is how the Portland breakwater was made, and Fig. 2 shows the form of section to which it has been brought by the action of the waves. On the seaward side there is first a long, gently sloping beach where the breakers act, and below this is a shorter, steeper slope, where the material lies very nearly at the angle of repose which it would assume under the action of gravity. The form of the breakwater is said to be practically permanent, in spite of the fact that it is constructed of loose materials, It must be borne in mind that the breakwater is not situated like a sea-wall, but is supported by the water on the harbour side.

When waves are raised by wind we are not practically concerned with the expenditure of energy in their formation; but it is otherwise with the waves raised by ships, which retard the progress of the vessel by using up a part of her energy of motion. The resistance which water offers to the progress of a ship is of two kinds: skin resistance and wave-making resistance. As the speed of a ship increases, the wave-making resistance increases much more rapidly than the skin resistance, so that at high speeds the wave-making resistance may become equal to, if it do not exceed, the skin resistance; in other words, at high speeds one half of the resistance to a ship's motion may be due to the work of wave-making. Where, as in the case of torpedo-boats, high speed has to be attained by a vessel of small size, it is especially important that all the circumstances of wave-making should be carefully considered in settling the lines of the vessel.

In our next article we shall describe in detail the beautiful pattern of waves which is formed in the track of a ship.

OUR FUR PRODUCERS.—II.

SABLE, MINK, ERMINE, AND RACCOONS.

By R. Lydekker, B.A.Cantab., F.R.S.

In the preceding article of the present series we discussed the more aberrant fur-yielding members of the *Mustelidæ*, and there now remain the typical representatives of that family, or those which may be included in the genus *Mustela*. All these animals, which are severally known as martens, ermines, polecats, and weasels, are characterized by their long bodies and short limbs; and nearly all yield fur of a certain commercial value, while that of some species commands a very high price in the market.

To the larger members of the group, or those characterized by the possession of five pairs of upper and six of lower cheek-teeth, the general name of martens might be applied. Foremost among these, on account of the high value of its fur, stands the sable, or Siberian marten (*M. zibellina*), of Eastern Siberia and Kamschatka, which is a near relative of our own yellow-breasted or pine-marten (*M. martes*). Indeed, there is very considerable doubt whether the sable is entitled to rank as anything more than a local race of the latter species, distinguished by its finer and more abundant fur. In the pine-marten the general colour of the pellage is rich dark brown, but the breast has a light patch of variable size, which is generally some shade of yellow, although its tint may be anything between orange and creamy white; the under-fur being reddish grey with yellow tips. The usual length of the head and body varies from about sixteen to eighteen inches, while the bushy tail measures from nine inches to a foot. In the sable there is less variability of colour, brown and dark brown being the general hue of the fur; but occasionally light brown examples, or specimens with an admixture of silvery hairs, are met with, and in rare instances perfectly white sables are found. Light-coloured varieties appear to be most common in Kamschatka, which yields the largest quantity of sable that comes to market; whereas Siberian skins are generally the darkest, and consequently the most valuable. The highest priced pelts come from the province of Yakutsk; and next to these are those from Okhotsk, although they are of smaller size and less deep colour. The length and quality of the fur varies much with the season, sable killed in summer being of but slight value, and those killed in winter alone commanding a high price. Sable are always skinned entire from the tail forwards, so that the pelt, when removed, forms a bag.

For their size, winter sable-skins command, perhaps, the highest price of any pelts. In Kamschatka, according to Dr. Guillemard, the peasants receive, on an average, about sixteen roubles* per skin; but in St. Petersburg the price of the pelts varies from two pounds to upwards of twenty-five pounds each, and it is stated that as much as thirty-three pounds has been given for unusually fine dark-coloured specimens from Yakutsk. Silvery pelts are those for which there is the greatest demand in Russia, while dark specimens meet with the greatest favour in the markets of London and Paris. From Amurland, where Mr. Poland states from twelve thousand to twenty thousand sables are killed yearly, the greater number of skins are exported to China, where they are used for the robes of the Mandarins. In these the tails are not required, so the latter find their way into the London market, where they sell at from two to six shillings apiece, and are made into boas and trimmings. In Kamschatka about two thousand sables are annually caught; and in 1891 the number of skins sold in London alone exceeded nine thousand.

In Kamschatka, Dr. Guillemard writes that "there are various methods employed in catching sables, but a less number are trapped now than used formerly to be the case. Dogs are almost invariably employed to run them down in the deep snow or to tree them; and they are also smelt out by these trained animals in their holes at the roots of trees. The great object is to tree the sable, if possible.

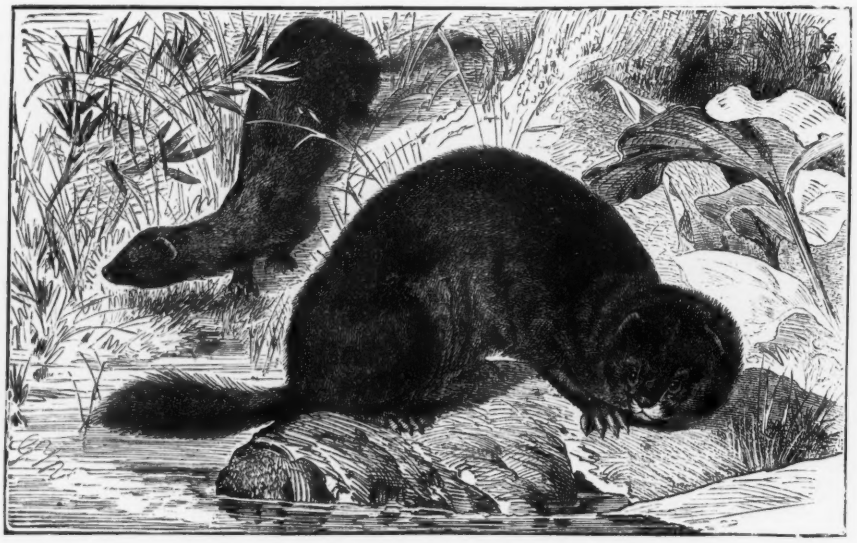
* The value of the paper rouble is about half a crown, and that of the silver rouble three shillings and sixpence.

The hunter then surrounds the base of the tree with nets, and either shakes down his quarry or knocks it off the boughs with sticks. If it does not fall into the net it is run down by the dogs, or again compelled to take refuge in a tree. Should the tree be too high for this method to be successful it is cut down, or the sable is shot; but the hunters generally avoid the use of the gun if possible, as it is apt to spoil the skin."

The pine-marten, which, although now scarce in Britain, is still abundant in many parts of Europe, is much less valuable than the last, skins averaging about half a sovereign apiece. The greater number appear to come from Lithuania and Courland, on the Baltic, whence the annual exportation amounts to about three thousand.

Very closely allied to the two last is the American marten or sable (*M. americana*). It is stated to differ from the pine-marten by certain characters of the teeth, while its fur is generally darker and subject to greater variation in tint. Regarding its relationship to the true sable, Dr. Coues observes that "the animal is, to all external appearance, indistinguishable except in some of those slight points of pellage which, through the whims of fashion, affect its commercial value; but there may be a technical zoological character of importance in the teeth." Probably we shall not be far wrong in regarding the two forms as local varieties of a single widely-spread species, although this is not the view of modern American zoologists. This marten has a wide geographical range in the northern half of the American continent, where it was formerly very abundant, upwards of fifteen thousand skins having been sold by the Hudson Bay Company in the year 1743, while about the same time thirty thousand were imported by the French from Canada. During the present century over one hundred thousand skins have been exported in a single year by the former company; and as late as 1891 they sold over sixty-four thousand, nearly forty thousand being accounted for in the same year by other traders. Great fluctuations occur in the value of these skins, which of late years has tended to depreciate; and in 1892 the range in price, according to quality, fluctuated between half a crown and two guineas each. There appear to have been good and bad "marten years," as is attested by Pennant, who wrote that once in two or three years these animals "come out in great multitudes, as if their retreats were over-stocked; this the hunters look on as a forerunner of great snows and a season favourable to the chase." A later writer, Mr. Ross, adds that the marten "occurs in decades or thereabouts with wonderful regularity, and it is quite unknown what becomes of them. They are not found dead. The failure extends throughout the Hudson Bay territory at the same time. And there is no tract or region to which they can migrate where we have not posts, or into which our hunters have not penetrated. When they are at their lowest ebb in point of numbers they will scarcely bite at all [at the baits of the traps]. Providence appears thus to have implanted some instinct in them by which the total destruction of their race is prevented."

In spite of the vast numbers destroyed for the sake of their pelts, these martens appear to hold their own so long as the country is left in its original wildness. Directly, however, civilization makes its presence felt they begin to diminish rapidly, and soon disappear completely; their shy and suspicious nature rendering them incapable of existing in the neighbourhood of human habitations.



The European Mink (One-third natural size).

Another species of the group, of which but comparatively little is known, is the Japanese marten (*M. melanopus*), its fur being distinguished by its light yellow. Commercially the pelts, of which from two to five thousand are imported annually into London, are of but small value, now averaging only from one to two shillings each.

The beech-marten or stone-marten (*M. foina*), sometimes also known as the white-breasted marten, is widely distributed over Europe and Northern Asia, but is a more southern form than the pine-marten, being unknown in the British Islands and Scandinavia. From the species last mentioned it may be readily distinguished by the dull greyish hue of the fur of the back and the pure white of that of the throat. There are likewise still more decisive differences to be found in the conformation of the skull and teeth, the former being relatively wider than in the pine-marten. The great market for the pelts of this species is Russia, but it is difficult to form any estimate of the number which annually change hands or the price they realize. The finest skins are stated to come from Bosnia.

By far the most striking in appearance of the whole group is the Indian marten (*M. flavigula*), which inhabits the hills of India and some of the Malayan countries, and is distinguished by the deep blackish brown colour of the upper-parts and the bright orange or yellow of the chest. Although pelts of this handsome marten sell for about seven shillings apiece, they are so seldom brought into the market that they form no essential element in the fur trade.

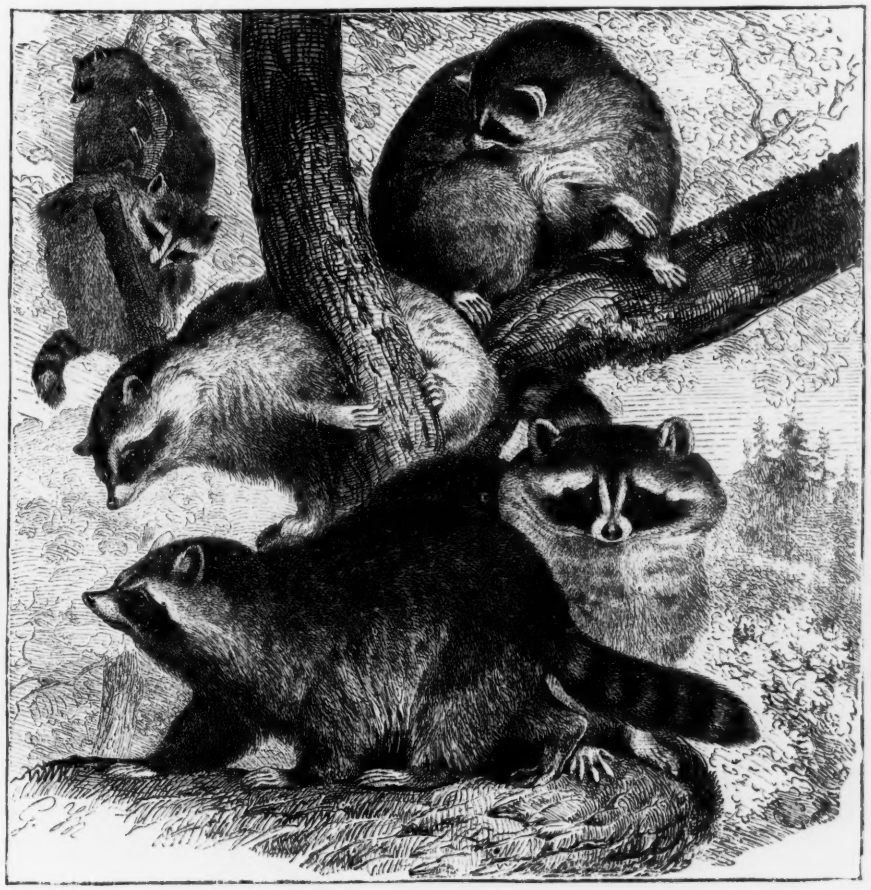
Very different from all the foregoing is Pennant's marten (*M. pennanti*), also known as the pekan or fisher-

marten, which is a North American species of the size of a fox. As it is likewise more fox-like than other martens, it is commonly termed the "black fox" by the trappers. In general colour it is blackish, darker below than above, and becoming greyish on the fore parts of the body and head. It apparently derives its name of fisher-marten from frequenting moister situations than others of its kind, although there does not seem any evidence that it catches fish. Indeed, its favourite prey is stated to be the Canada porcupine, which it kills by biting on the unprotected lower surface of the body. The finest skins are obtained from northern Canada, and these may fetch nearly four pounds each, although inferior specimens are sold for as little as three and sixpence. In 1891 between eight and nine thousand skins of this species were sold, the great majority by the Hudson Bay Company.

The mink (*M. vison*), which is typically a North American form, although it is represented by a closely allied species (*M. lutreola*) in Eastern Europe, is the first and largest member of the second great group of the genus *Mustela*. From the martens all these animals differ in having only four pairs of upper and five of lower cheek-teeth, as well as by certain structural differences in some of these teeth. On account of these and other points of distinction they are frequently separated as a genus, under the title of *Putorius*. Most of them are much smaller than the martens; but this is scarcely the case with the minks, which measure from fifteen to eighteen inches to the root of the tail. The pellage of these animals is remarkable for its rich silky gloss, the usual colour being a full dark brown, passing into black on the tail; the chest, like that of the pekan, being generally of the same dark tint as the rest of the fur. In habits the minks differ markedly from their allies, being amphibious animals, and subsisting partially upon fish, although they also kill and eat large numbers of the smaller mammals. Like the polecats, minks are decidedly ill-smelling creatures.

Although the fur of the mink is short it is extremely durable, and on this account, as well as from its beautiful gloss, it was at one time held in considerable estimation, and skins have been known to fetch as much as thirty shillings each. Of late years, however, it has declined in favour, and skins of the American species, according to Mr. Poland, now sell at from five pence to a guinea, while those of the Russian kind do not appear to exceed five shillings. Still, in spite of this depreciation in price, mink skins form a very important article of trade, upwards of three hundred and sixty thousand American pelts having been sold in London in 1890, and over two hundred thousand in the following year. Mr. Poland states that mink skins are chiefly used for muffs and coat-linings, while the tails are made into capes. The fur may be used either in its natural condition, or pulled and dyed to imitate sealskin.

The polecats, of which there are several kinds distributed over the northern parts of both the Old and New Worlds, yield a short fur of inferior value, which is known in the trade by the name of "fitch." The European polecat



The Raccoon.

(*M. putorius*), which is too well known to require anything in the way of description, has the fur of the upper-parts dark brown, and that of the lower surface of the body and the tail black. But in the Siberian species (*M. eversmanni*) the back and head are covered with a nearly white fur. Like many other kinds of the commoner furs, fitch is of less value now than formerly; and whereas in the first quarter of the century the price was a little over four shillings per skin, it now varies from three shillings to eighteen pence. Although somewhere about two hundred thousand European pelts are sold annually at the Leipsic fair, but few find their way into the English market; and these, it appears, are chiefly employed for trimming aldermanic robes.

XUM

Of the smaller species of the genus by far the most valuable commercially is the ermine, or stoat (*M. erminea*), which in the more northern portion of its habitat turns wholly white in winter, with the exception of the black tip of the tail. And it is only these white winter skins that have any commercial value. Like the weasel, which also turns white in winter in the colder part of its habitat—even to the tip of its tail—the ermine is an inhabitant of both the Eastern and Western Hemispheres; and in the former the finest skins are the produce of Siberia. Ermine is chiefly used for the lining of state robes, the black-tipped tails forming an essential part of the fur. "It was once regarded," writes Mr. Poland, "as a princely fur, and only to be devoted to the use of royalty; but it has now become very much neglected, and a few years ago it was practically unsaleable. . . . The skins are very neatly tied up with bass in bundles of ten, twenty, or fifty. They are sold by the timber (forty skins). The present market value is twenty to thirty shillings per timber, and a few years ago it was even less. The highest price recorded for good skins is one hundred and eighty shillings per timber; two hundred and sixty-four thousand, six hundred and six skins were imported into London in 1836." Miniver is the fur of the ermine marked with black spots, instead of having the whole tail affixed. "Greybacks" are skins taken from animals at the time they were commencing to turn white for the winter.

With regard to the change of colour of the ermine at the commencement of winter, it was at one time considered that this was coincident with the autumnal shedding and renewal of the coat; that is to say, that the brown summer dress was shed, and replaced by the white one of winter, without any actual bleaching of the hairs themselves. That this is very generally the case has been conclusively proved by actual experiments. It has, however, also been shown that if an ermine that has assumed its winter dress in a temperate climate—when it will be of the dark summer hue—be subjected to a sudden or gradual lowering of temperature, its brown coat will soon turn pure white, thus showing that the individual hairs are capable of changing their colour.

The ermine closes the list of *Mustelidæ* important as fur producers, and we accordingly pass on to the much smaller group of the raccoons, or *Procyonidæ*. With the exception of a single Himalayan species, representing a genus by itself, the whole of these carnivores are American, the majority inhabiting Central and South America. From the weasel tribe they may be distinguished by possessing two pairs of upper molar teeth; and very generally the tail is marked by alternating dark and light rings, which is never the case in the former group.

The only species of any importance in the fur trade is the common North American raccoon (*Procyon lotor*), which extends over the whole of the United States, ranging towards the north-west into Alaska, and southwards into Central America. The southern examples are larger than the northern race. In size, the raccoon may be compared to an ordinary badger. It is a somewhat clumsily-built animal, with a sharp nose, small ears, plantigrade feet, and a short bushy tail, marked with narrow rings of black and white and generally having the tip black. The fur of the body, which is long, thick, and soft, is of a general greyish brown colour; but fawn-coloured or white examples are occasionally met with. Raccoon fur is an item of considerable importance in the trade; the best pelts coming from Wisconsin and Illinois, those from the southern portions of the animals' range having coarse and short fur. About half a million skins, ranging in price from sixpence to ten shillings, are sold yearly in the London markets; but unusually dark-coloured specimens may fetch as much as thirty shillings. Pale-coloured pelts are generally dyed black or brown, and when "pulled" the fur is often used to imitate beaver. Raccoon-fur is much used for coat-linings, but the better descriptions are employed for trimmings and capes; and, when clipped, it is sometimes manufactured into glove-tops. The prettily marked heads are not uncommonly seen mounted to ornament fur foot-warmers, and the tails are employed in rugs and boas.

Raccoons have less powerful teeth than the majority of the Carnivora, indicating that they are less addicted to a flesh diet; and, as a matter of fact, they are almost omnivorous creatures, feeding on nearly everything eatable that they may come across. They are good climbers, and are most generally found in the neighbourhood of water. Raccoon-hunting is generally undertaken with the aid of dogs; the animal being first treed, and then shot.

Were it not for the scarcity of the animal, the fur of the panda, or Himalayan raccoon (*Ælurus fulgens*), would form an important item in the trade; but since very few pelts come into the market it is necessarily but little used. The fur of the upper-parts is of a beautiful rich reddish brown, but is considerably darker on the lower surface of the body, the long tail being marked with broad reddish rings separated by narrower ones of black. The few skins that come into the market sell at from seven shillings to a guinea each.

PHOTOGRAPH OF THE "CRAB" NEBULA, MESSIER 1 TAURI.

By Isaac Roberts, D.Sc., F.R.S.

R.A. 5h. 28m., Decl. N. 21° 57′.

THE photograph covers a region of the sky equal to nineteen minutes of arc in diameter.

Scale, one millimètre to six seconds of arc.

The photograph was taken with the 20-inch reflector on January 25th, 1895, between sidereal time 4h. 30m. and 5h. 30m., with an exposure of the plate during sixty minutes.

References.

The nebula is N. G. C., No. 1952; G. C., No. 1157; h 357. Rosse, *Observations of Nebulæ and Clusters of Stars*, p. 47. It is figured in the *Phil. Trans. of the Royal Society*, 1833, Pl. XVI., Fig. 81, and in 1844, Pl. XVIII., Fig. 81; and also by Lassell, *Mem. of the Royal Astronomical Society*, Vol. XXIII., Pl. II., Fig. 1.

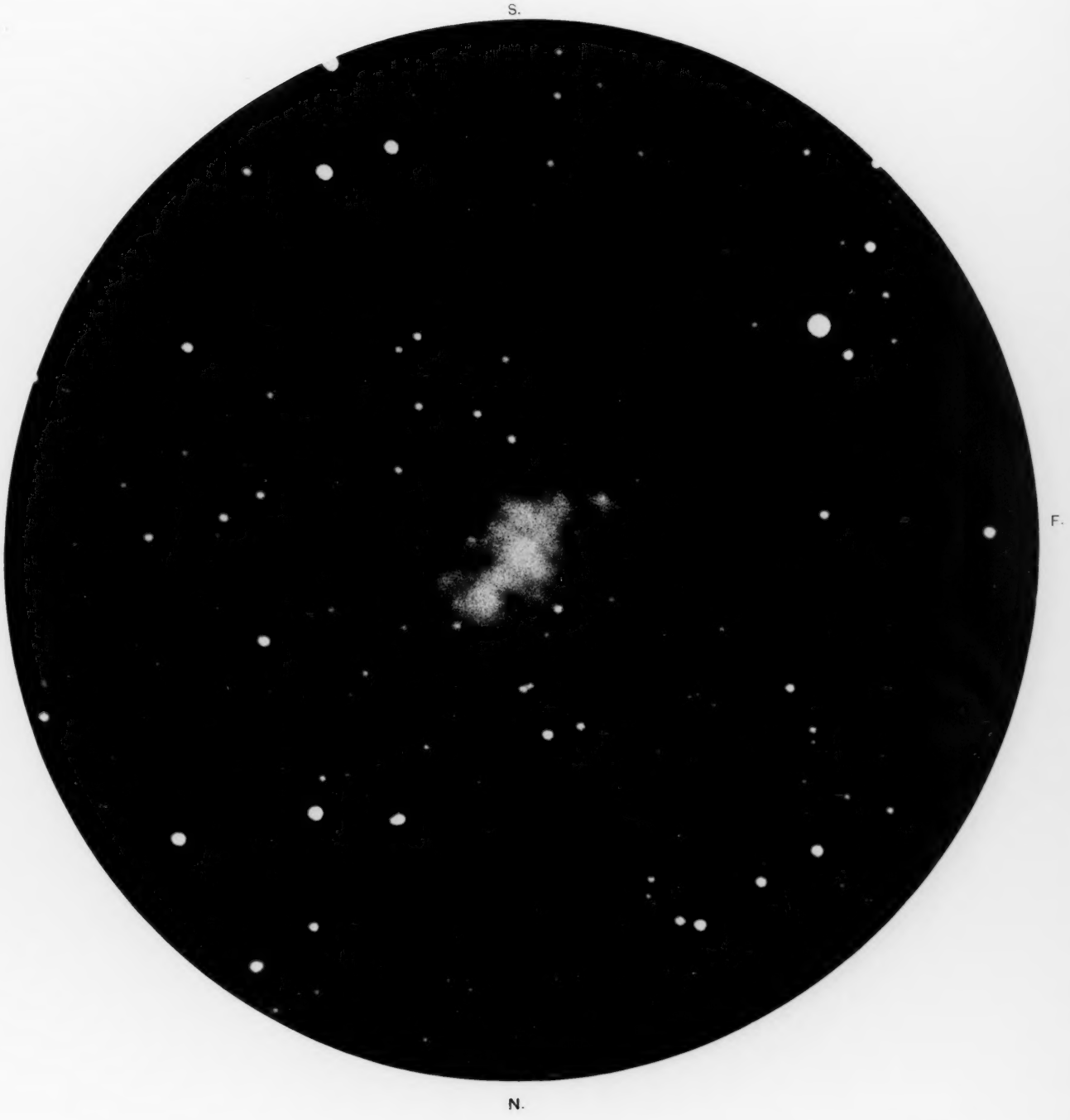
The drawings and the descriptive matter, referred to above, do not convey to us the same ideas as we gather from the photograph.

The photograph shows the nebula to be elongated in *south following* to *north preceding* directions; irregular in outline, and somewhat resembling an island with deep embayments at intervals round its margin.

More clearly than it is practicable to reproduce in a print, the negative shows mottling and rifts in the nebula. One rift curves round the *north following* margin, another extends across from the *north following* to the *south preceding* side, with a star of about the 14th magnitude at its centre. There are also some star-like condensations involved in the nebulosity.

A photograph of this nebula, taken on the 25th January, 1890, is given in the volume of *Photographs of Stars, Star-Clusters, and Nebulæ*, Pl. XIV., which shows the nebula and the surrounding region of the sky on the scale of one millimètre to twenty-four seconds of arc.

PHOTOGRAPH OF THE "CRAB" NEBULA, MESSIER 1 TAURI.
By ISAAC ROBERTS, D.Sc., F.R.S.



XUM

[The "Crab" nebula, discovered in 1731 by Bevis (who, after the death of Bliss, the fourth Astronomer Royal, became a competitor for the vacant place), was rediscovered in 1758 by Messier, the "comet-ferret" of Louis XV., and was the occasion of Messier's drawing up his catalogue of nebulæ. This, practically the first catalogue of the kind, was published in 1771, and contained forty-five objects, at the head of which was the nebula with which we are now concerned. His second catalogue, published ten years later, included one hundred and three.

The "Crab" owes its name to the filaments springing from it, as the arms spring from a cuttle-fish, which are represented in the well-known drawing by the elder Lord Rosse. Lassell also represents various projecting appendages, but these do not confirm those recorded by Lord Rosse. There is, however, nothing crab-like in the beautiful photograph of it which Dr. Roberts has produced, nor do the later observations made with Lord Rosse's reflector bear out the earlier descriptions of the claws. The name, therefore, as indicating the shape of the nebula, appears a misnomer. It might, however, be still applicable in the oarsman's sense, for not a few tyros in the art of comet-seeking have been deluded by Messier 1, and have had sorrowfully to confess that they have "caught a crab." Perhaps no object in the heavens has been so often mistaken by beginners for a comet.—E. W. MAUNDER.]

ANOTHER DARK STAR.

By MISS A. M. CLERKE, *Authoress of "The System of the Stars," and "A Popular History of Astronomy during the Nineteenth Century," &c., &c.*

ONE hundred and seventeen years ago the star catalogued by Flamsteed as 70 Ophiuchi was discovered by William Herschel to be an easily-divided, unequal pair. Their mutual revolution quickly became apparent, and by 1872 the companion had resumed its original position *precisely* east of its primary. A period of ninety-three years was thus, it might be thought, emphatically asserted; yet the assertion has not been borne out by facts. The star is now certainly known to have been behind time in returning to the starting point. Left to itself, it would have accomplished the circuit in eighty-eight years. But it was not left to itself; and its unmanageability on the supposition of undisturbed elliptic motion is forcibly illustrated by the circumstance that periods ranging from seventy-three to ninety-eight years have been assigned to it by skilled computers, most of them with ample materials at command.

Few double stars have received so much attention as 70 Ophiuchi. It is a beautiful object to view, and a tempting one to measure; hence, all sorts and conditions of star-gazers have tried their hand at it. Much "grey matter," too, has been wasted in efforts to rationalize its movements. Encke exemplified with it, in 1830, his brand-new method for determining stellar orbits; Sir John Herschel followed with a less rigorous, though more satisfactory *modus operandi:* and they have had not a few imitators. The stars, meanwhile, preserved their independence, taking slight heed of the various and sundry orbits assigned to them, from which they diverged unaccountably and at once. Perturbations were tolerably evident; and Captain Jacob, the East India Company's astronomer at Madras from 1848 to 1859, hazarded the conjecture that the visible companion, while circuiting its primary in eighty-seven and a half years, described a secondary ellipse round an invisible or at least undiscerned body once in twenty-six years.* Sir John Herschel held a similar opinion, and the persuasion of the star's triplicity was so general that Mr. Burnham thought its telescopic verification worth some pains; but, neither with the Dearborn eighteen-inch, nor with the Lick thirty-six inch, could either of the components be subdivided; each alike was pronounced "round, with all powers."

At last, in 1893, Dr. Schur, of Göttingen, collected all his Teutonic patience for an attack in form upon the star.† His work was ably done. If the anomalies which had occasioned so much perplexity could have been got rid of, his skilful manipulation would have accomplished the feat. But his ellipse had not been obtained, so to speak, in the natural course. The observations of distance proving incompatible with the observations of position-angle, he had uncompromisingly rejected the former, and relied exclusively upon the latter; and even these had been subjected to suspicious corrections, implying a consensus of error between various excellent observers, now in one direction, again, after some lapse of time, in the opposite. Moreover, his elements stood very ill the test of prediction.

"While engaged recently," Dr. See writes,‡ "in the observation of double stars at the Leander McCormick Observatory of the University of Virginia, I took occasion to measure 70 Ophiuchi on three good nights. On comparing the results with Schur's ephemeris, four months later, I noticed with surprise that the observed angle was over four degrees in advance of the theoretical place. As the Virginia measures had been made under favourable conditions and with extreme care, it became evident that the orbit to which Professor Schur had devoted so much attention would need revision."

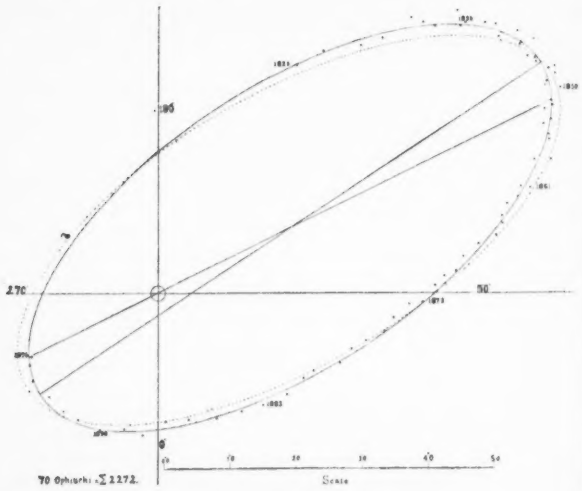
He accordingly undertook the unruly star, and laid down for it an ellipse differing little from Mr. Burnham's in 1893,§ or from Mr. Gore's in 1888.‖ But this did not satisfy him. Comparing one by one the recorded and theoretical places of the revolving object, he detected systematic discrepancies, acceleration repeatedly alternating with retardation. Their genuineness was confirmed by an examination of Dr. Schur's *apparent* orbit—obtained by projection from the elements of his *real* one—showing departures from the observed distances corresponding to the departures from the observed rate of progress by which Dr. See's own calculations were, to a certain extent, vitiated. "We were thus," he remarks, "confronted with a case in which it was apparently impossible to satisfy both angles and distances."

In the accompanying figure, the dotted line represents Schur's ellipse; the smooth line, that constructed to accord with the measures of last year. Both are projections of the actual orbit upon a plane at right angles to the line of sight. So that they profess to portray just the visible facts of revolution, the larger star, as usual, being assumed for convenience to be stationary. The two curves—Dr. Schur's, it will be remembered, based upon angles alone, Dr. See's upon angles and distances alike—differ with curious regularity, one cutting the other at fixed intervals, as it runs in and out. Both are evidently drawn with dexterity and judgment; it would be time thrown away to try and improve upon them; yet neither accommodates itself within plausible limits to the given conditions. The stars were, in point of fact, by turns closer together and farther apart than they ought to have been according to the Göttingen calculations; they

* H. Sadler, *English Mechanic*, Vol. XLI., p. 410.
† *Astr. Nach.*, Nos. 3220-1.
‡ *Astronomical Journal*, No. 363.
§ *Astronomy and Astrophysics*, June, 1893.
‖ *Monthly Notices*, Vol. XLVIII., No. 5.

moved alternately quicker and slower than they were licensed to do at Chicago. And this not fallaciously, through a chance concurrence of deceptive data, but by "a law of order" in a "settled kingdom."

Dr. See tells us what this law is. The difficulties of his predecessors have proved to be his opportunity. They



arose from the attempts, necessarily futile, to treat a ternary as a binary star. His discovery—for such it may be termed—of an obscure disturbing body in the system of 70 Ophiuchi exemplifies yet once more the value of "residual phenomena"—of vexatious incongruities undermining accepted arrangements, and bringing in their train, for many a long day, nothing but experimental failure and mental discomfort. Only by the severe treatment prescribed by modern methods can their true meaning be extracted. They have to pass through an ordeal of strict measurement, from which they emerge, if real, definite and unmistakable, while the collapsible sort vanish and are heard of no more. Instances of each kind of result might be cited, but we are here concerned with one that is solid and satisfactory.

There can no longer be any reasonable doubt that 70 Ophiuchi is a triple star, composed of two veritable suns, linked with a body highly influential upon movement, though devoid of appreciable luminous power. Coupled with the shining satellite, it describes round the chief star an orbit of more than planetary eccentricity in a period of eighty-eight years, while revolving in thirty-six round its immediate companion. Now the parallax of this object, reliably determined by Dr. Krüger, at Bonn, in 1858-1862, amounts to about one-sixth of a second of arc, corresponding to a light journey of twenty years.* Hence the mass and dimensions of the system are at once known. Taken together, the three bodies of which it consists possess 2·8 times the gravitative force of the sun; and the mean radius of the path pursued by the subordinate pair is twenty-eight times the distance of the earth from the sun, that of the orbit of Neptune being thirty times the same unit. The stars are, however, at present, separated by only one-third the gap of space which will yawn between them in the year 1940. For they are just now very near—almost at—periastron, and that point of closest approach, transplanted to the solar system, would be situated about midway between the orbits of Saturn and Uranus, while the apastron passage will take place no less than eleven hundred millions of miles beyond the region of Neptune's tardy circulation.

Turning to the secondary system of 70 Ophiuchi, we find the bright component revolving round its centre of gravity at a distance nearly twice that of the earth from the sun, its round of travel being thus considerably wider than the orbit of Mars. The apparent radius of its path is about one-third of a second, and, if the dark body to which it is attached be of equal mass, the interval dividing them is twice as great, so that Dr. See does not despair of its telescopic discovery. For it may not be wholly destitute of stellar lustre; and if clothed with even the imperfect luminosity of the companion of Sirius, it might, although much smaller, and more than twice as remote, be nevertheless detected with the Yerkes refractor. A single measure of its place would suffice to determine its mass, which must otherwise remain unknown.

The distribution of matter in stellar systems is a point of great interest, and of equal difficulty. Relative brightness is no guide to it. Satellite-stars are often attractive out of all proportion to their magnitude. Sirius emits ten thousand times more light than its attendant, yet it is only twice as massive. The stars of α Centauri bear equal sway in the system formed by them, notwithstanding the fivefold superiority in brilliancy of one over the other; and a corresponding disparity seems to exist in the beautiful tinted couple η Cassiopeiæ. Here the yellow primary surpasses its rosy attendant twenty-eight times in light, though no more than three times in mass, according to M. Otto Struve's location of their centre of gravity. Prof. Jacoby, however, proposes to test the accuracy of his result by measurements from the Rutherfurd photographic plates; and intrepid computers will no doubt come forward to execute his plan, which demands the solution of seven hundred and two equations involving sixty-six unknown quantities.

Endless gradations of radiative power seem to be represented in the stellar world; but the discovery of "dark stars," solely through their gravitational effects, must be regarded as a signal triumph of exact astronomy. They are found under varied circumstances. Witness the companion of Procyon, unseen, not assuredly through proximity to that lustrous orb, but through real obscurity; the fourth component of ζ Cancri, and the almost incredibly close satellites of Algol and other eclipse-stars, as well as of δ Cephei, and sundry short-period variables; besides an unknown multitude of undiscoverable orbs, which have ceased or never began to shine, or even of whole systems wrapt in thick darkness.

Dr. See reminds us that, for the carrying out of the geometrical plan of movement in 70 Ophiuchi, it is a matter of indifference whether the obscure component be attached to the larger or to the smaller star. "While we have spoken," he remarks, "of the dark body as attending the companion, it is clear that similar phenomena would result from the action of a body revolving round the central star. In this case, however, the considerable distance which would result from a period of thirty-six years might render the stability of the system somewhat precarious."

Perhaps more than precarious. The alternative arrangement could apparently subsist throughout a single revolution only by a happy chance. For if we ascribe to the central star and its big planet a combined mass twice

* There seems no good reason for superseding as yet Krüger's parallax of 0″·162. Schur's few recent measures were made under such unfavourable conditions as to deserve, in his own opinion, little confidence.—*Astr. Nach.*, No. 3231.

that of our sun, the mean distance corresponding to a period of thirty-six years would be roughly one thousand three hundred million miles. But, since stellar orbits are mostly very elongated, their separation would, by a safe presumption, greatly transcend and fall short of this measure every eighteen years. Now the visible companion sweeps through periastron at a distance of fourteen hundred million miles; an actual collision, then, with its inconspicuous colleague (using the word in its strict sense) would be no improbable event; and approaches so close as to involve a complete subversion of the system could scarcely be averted. The conclusion is thus fully warranted that in 70 Ophiuchi the companion is the duplex star.

The combined spectrum of the pair was registered by Vogel as of the solar type, for the Arcturian variety of which it is claimed in the Draper Catalogue. Their rays have not yet been separately analyzed; indeed, so delicate an operation is scarcely yet feasible.

The colour of the smaller object of 6·5 magnitude appears subject to change. White, with "an inclination to red," in the elder Herschel's time, it showed to his son and to Sir James South as "livid"; Struve found it purplish; Admiral Smyth, violet; Flammarion, in 1879, termed it rose-coloured; while some intermediate observers recorded it as yellow; and yellow it now indisputably is. There is, in fact, no perceptible difference between its hue and that of its 4·5 magnitude primary. It will be curious to notice whether chromatic divergence sets in as they retire from periastron.

The mechanism of the system must be exceedingly intricate, but can scarcely, for many decades to come, be submitted to detailed investigation. Dr. See barely indicates the arduous nature of the task; we trust that his own powers may one day be employed in grappling with it. By that time, possibly, mathematical resources may have developed to meet the urgency of the demands made upon them by sidereal science. It is certain that the very highest powers of the human mind will be called into play for the solution of the multitudinous problems unfolded by the stars.

[There is just one addition I should like to make to Miss Clerke's graphic and striking account of a fact which must soon bulk largely in astronomical literature. Dr. See has drawn public attention to an interesting feature of the system of 70 Ophiuchi, and he has been the first to actually compute the movements of the companion on the assumption of an unseen third star. But this work can hardly be entitled a "discovery." The presence of the third member has long been postulated amongst those who have devoted themselves to the close study of double-star orbits. Nor does 70 Ophiuchi stand alone in this respect, and herein lies the exceeding importance of the subject. Fully ten per cent. of the best known binary systems show irregularities as truly periodic in character; many of them are even more pronounced and striking. Amongst others I might refer to 36 Andromedæ, ζ Herculis and λ Ophiuchi, and the beautiful pair referred to above by Miss Clerke, η Cassiopeiæ. The "dark companion" is not a rare exception; it has already been recognized in many instances, and future observations will certainly add to the number.

I would also emphasize Miss Clerke's objection to Prof. Schur's method of rejecting the measures of distance in the computation of an orbit. With modern appliances these are at least as trustworthy as the observations of position-angle, and their rejection nowadays can only be condemned as a discarding of important material.—E. Walter Maunder.]

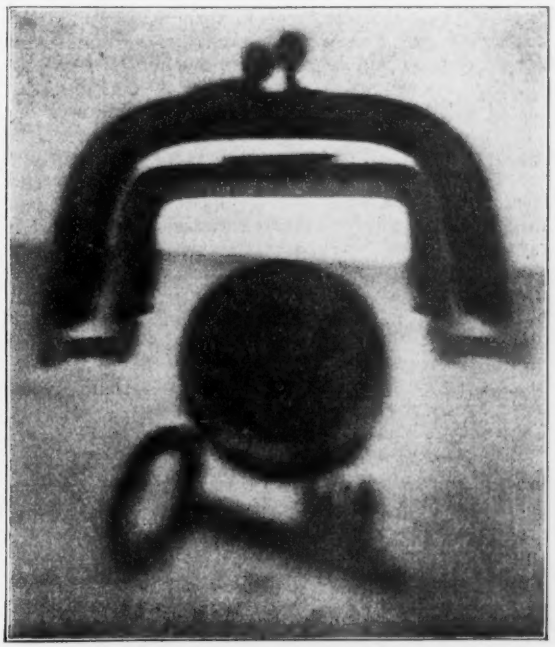
PHOTOGRAPHY OF INVISIBLE OBJECTS.

By J. J. Stewart, B.A.Cantab., B.Sc.Lond.

In his presidential address to the Royal Society in the year 1893, Lord Kelvin predicted that future discovery with regard to the relations of the luminiferous ether and ponderable matter would have as its basis knowledge obtained from experiments on the discharge of electricity through highly rarefied gases. What has taken place in the two years which have elapsed since that address was given has abundantly verified the correctness of Lord Kelvin's view as to the line along which future advance in physical science would take place.

The latest discovery in this department of knowledge has been of unusual interest, and has excited widespread attention beyond the limited circle of those more directly occupied with scientific work. Prof. Röntgen, of Vienna, has just published an account of some remarkable experiments he has been carrying out, and the results already attained are in themselves of great importance, whilst the possibilities of future insight into the nature of the ether which they open out cause them to be of intense interest to physicists.

It may be of interest to the readers of Knowledge to have put before them a short statement of the facts discovered and the methods of experimenting employed by Prof. Röntgen. He found that when he caused an electric discharge from an induction coil to pass through



Photograph of a Leather Purse, showing metal clasp, coin, and key inside. By Dr. Dawson Turner.

a Hiltorf's vacuum tube, or a tube containing a high vacuum like those employed by Crookes and Lenard, he got bright fluorescence produced on a piece of paper covered with platino-cyanide of barium, and this fluorescence was excited even when the tube itself was completely covered over with blackened paper so that nothing within it was visible. Moreover, the fluorescent

glitter was visible whichever side of the painted paper was next the tube—that with the coating of barium platino-cyanide upon it or the other—and the appearance was produced when the paper was held several feet from the tube. In a similar way fluorescence was caused in many other substances, such as uranium, glass, rock-salt, etc. On interposing a thick book with a thousand pages between the discharge tube and the fluorescent screen, the fluorescence was still generated, the discharge or the effects it gave rise to being evidently able to pierce not only the blackened sheet next the glass, but many folds of paper.

On repeating these and similar experiments, using instead of a fluorescing screen a sensitive photographic film or dry plate, Prof. Röntgen got impressions or shadow pictures formed on the sensitive surface. Thus photographs, if we may call them such, could be taken while the sensitive plate was kept inside a wooden box, and the operations could be performed in daylight, the plate never being exposed to light, but preserved throughout in a wooden or cardboard box. It also became necessary to guard the plate from the effect of the discharge when it was not in use, shutting it up in a box being no protection.

Further researches showed that pine wood was easily penetrable by the rays. They may be called *rays*, for their effects on sensitive films are similar to those of the ultra-violet actinic rays, though whether these effects are due to the direct action of the rays, or to secondary phenomena resulting from the production of fluorescence and chemical change at the plate's surface, is not yet settled. Not only are paper, wood, leather, and suchlike materials transparent to these rays proceeding from a vacuum tube in which a discharge is going on, but metals and almost all substances are so to a certain degree. The amount of obstruction placed in the way of the rays by different sorts of material varies very much. Amongst metals, aluminium is comparatively transparent, while lead is in comparison very opaque. Ebonite and india-rubber allow easy passage to the rays, while some varieties of glass obstruct them much—lead glass especially; though from the fact that the tubes used for the discharge are of glass, it is evident that the rays are by no means cut off by that material.

From the relative opaqueness of lead, gold, and other heavy metals, the investigator was led to compare the obstructive effects of substances as related to their density; and whilst it was found that the density or quantity of matter contained in unit volume played the principal *rôle* in causing stoppage of the rays, the amount of this obstruction or opacity was by no means proportional to the product of thickness and density.

Röntgen next went on to try if these rays were refracted or bent out of their course, as ordinary light rays are, on passing from a rare to a dense medium. The result obtained was striking; no appreciable refraction was obtained when prisms of glass or ebonite were used. When light was passed through the same prism considerable deviation in the beam was obtained, the comparison showing a remarkable difference in behaviour of light rays and the new rays. Similarly the rays cannot be concentrated by means of a lens. Experiments made to test reflection gave not quite decided results. Crosses or stars cut out of metal and placed above a sensitive photographic plate indicated their position by a dark trace or shadow. This apparently pointed to reflection at the surface of the metal, but Prof. Röntgen inclines to the belief that what takes place when the rays pass through a solid or liquid is more like the passage of light through a cloudy medium consisting of discrete particles.

The rays seem to traverse a medium separate from matter and contained between the molecules of all varieties of matter. Substances such as glass when powdered obstruct the passage of light, as is well known, owing to reflection at the manifold surfaces of the particles arranged at all angles. A powdered body placed in the path of Röntgen's rays does not obstruct them more than an ordinary transparent solid. This last experiment seems to indicate the absence of reflection.

What, then, can these rays be which thus behave so differently from light rays? It has been suggested that they are waves of light of very short wave-length far beyond the known ultra-violet rays. If the wave-length is very minute and comparable with the magnitude of a material molecule's diameter, we might expect quite different effects from those of ordinary refraction. The absence of refraction in Röntgen's new rays—the *x* rays as he calls them for shortness—seems to show that the velocity of these rays is the same in all kinds of matter.

Röntgen Ray Shadow-picture of a Living Human Foot. Exposure 8 minutes, through ordinary cardboard.

Experiment clearly shows that the vibrations in the ether to which the phenomena of light are due are transverse to the direction of propagation of the waves.* Now there may also be longitudinal vibrations, and some physicists consider that there must be such. It becomes a most interesting question:—Are these new rays manifestations of the possible longitudinal vibrations in the ether? On the answer which may be given to this question the principal scientific interest in Röntgen's discovery turns. The discoverer himself is inclined to answer the question in the affirmative. Sir G. G. Stokes, our greatest authority on light, considers that it is probable the phenomena may be explained without bringing in longitudinal waves in the ether. In the present open state of the question it is interesting to remember the remarks made by Lord Kelvin in his course of lectures at Baltimore in 1884. He said, referring to longitudinal or condensational waves in the ether: "We ignore this condensational wave in the theory of light. We are sure that its energy is very small in comparison with the energy of the luminiferous vibrations we are dealing with. But to say that it is absolutely null would be an assumption that we have no right to make." Later in the same address he went on to say: "But that there are such waves I believe; and I believe that the velocity of propagation of electrostatic force is the unknown condensational velocity that we are speaking of."

The velocity of propagation of such longitudinal waves is shown by mathematical calculation to be enormously

* *See* article on "The Luminiferous Ether" in KNOWLEDGE, 1894.

greater than that of the transversal vibrations, and may be spoken of as infinitely great. If the existence of such vibrations can be proved, and experimental evidence obtained as to the behaviour and effect of these longitudinal vibrations, a great step forward in our knowledge of the ether may be about to be taken. When it is remembered that the explanation of the cause of gravitation must be in some way bound up with the nature of the ether, it is easy to understand with what keen interest further developments of Professor Röntgen's work are looked forward to by all interested in the progress of science.

NOTE.—The photograph of a human foot was produced under the direction of J. A. C. Porter, Esq., and is published as a lantern slide by Messrs. Leo Atkinson, of Greenwich, by whom it was kindly lent to us for reproduction.

IN eclipses of the moon the brightness of the surface of the moon within the shadow of the earth depends upon the refraction and absorption of the sun's rays in passing through the earth's atmosphere. I. von Hepperger calculates the refractions and absorptions for various heights above the earth's surface, and from these are deduced the ratios between the eclipsed and ordinary luminosities for the various portions of the shadow. The estimation of the density of the atmosphere at various heights is based upon different theories and the facts as to the incandescence of meteorites. One conclusion reached is that at the beginning and end of totality the element of the moon's disc furthest from the centre of shadow is two or three hundred times as bright as the centre. As to the apparent excess of the size of the umbra beyond the geometrical shadow, this seems to be a physiological effect due to the fact that the eye cannot detect minute differences of brightness below a certain minimum of intensity.

Letters.

[The Editors do not hold themselves responsible for the opinions or statements of correspondents.]

COMETS.

To the Editors of KNOWLEDGE.

SIRS,—Mr. Plummer's interesting article on short period comets, and his mention of Mr. J. R. Hind in connection with them, recalls to my mind an incident in my early astronomical life which may be of interest, considering how recently Mr. Hind has been lost to us. On October 8th, 1858, I had the good fortune to be taken by a mutual friend to Mr. Bishop's observatory in Regent's Park, for the purpose of seeing Doneti's celebrated comet, then just passing its prime. Mr. Hind was of course there, showing the comet to the visitors. In the interval between the turns I got into conversation with the father of Mr. J. R. Hind, who told me that his son had had a taste for astronomy from the time when he was quite a small child, and that he was only twelve when he began regular work as an astronomer with an instrument which he (the father) had presented to his boy. I fear I have forgotten the immediate results of this boyish start, as stated to me, but the ultimate results are known throughout the world; for not only did Mr. Hind possess in a somewhat remarkable degree the gift of explaining in singularly terse and clear English any astronomical matter to which he applied his pen, but his letters to the *Times* through a period of fully forty years on astronomical matters in general and on comets in particular, furnished the general public with astronomical news up to date when writers on our science who appealed to the general press were few in number.

G. F. CHAMBERS, F.R.A.S.

MIRA CETI.

To the Editors of KNOWLEDGE.

SIRS,—After reading the discussion on Mira Ceti in your columns, I resolved to watch this star closely during the winter and spring months. Up to the end of 1895 it was invisible to the naked eye, and during the first two weeks of January cloudy weather prevented all observation.

Judge, then, of my astonishment when on the 15th inst. I perceived Mira to be of the $3\frac{1}{2}$ magnitude, quite conspicuous to the naked eye!

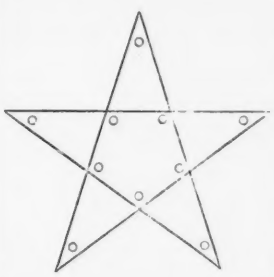
On the 19th it had increased to 3rd magnitude, and on the 23rd, with the moon nearly nine days old just above it, was easily visible as 3rd magnitude. On all these occasions Mira appeared, as seen either with glasses or through a telescope, of an orange colour. I should think that this sudden rise of this truly wonderful star is altogether unprecedented.

I ought to add that the only observation I know of previous to mine in January was made by Miss E. Brown (see *English Mechanic*, January 10th), who on January 2nd saw Mira as a 6th magnitude star or brighter, and previous to that, on December 15th, as 7th or $7\frac{1}{2}$ magnitude, while Mr. David Flanery (see *English Mechanic*, January 10th) saw it as $7\frac{1}{2}$ magnitude on December 17th. It would be very interesting to hear of any observations between January 2nd and January 15th. IVO. F. H. CARR-GREGG.

PENTACLE PUZZLE.

To the Editors of KNOWLEDGE.

SIRS,—A short time ago I sent a problem to your readers for solution, and now another equally interesting one has for some time occupied my attention. Perhaps some of your readers would demonstrate how many solutions can be given of it. There seems but one to me, but I cannot help thinking there must be five or more. The problem is to place the numbers 1 to 10 in the angles of a pentacle, as marked in the accompanying figure, so that each of the five sides shall count one and same number, and the five internal angles the same number, and the five external angles double the same number.



I. G. OUSELEY.

GEOGRAPHY AS A SCIENCE.

To the Editors of KNOWLEDGE.

SIRS,—The views which Dr. Mill has expressed on the nature of geography, in his paper on "Geography as a Science in England," in the January number of KNOWLEDGE, are similar to those which I have long held and which I have long known him to hold. But I am much struck by the freshness and vigour with which he has stated them. His practical suggestion of a geographical description to accompany the Ordnance Survey is also well worthy of consideration. The general idea of a careful geographical description of Britain is not new to me, but I frankly confess that I feel much nearer to it now that, in connection with the Ordnance map, it has taken such precise form in Dr. Mill's mind. One point only strikes me as requiring great caution. There is danger lest the band of workers contemplated should approach this task from various standpoints, many of them not geographical. Both English and German experience shows the likelihood

XUM

that specialists not trained in geography will miss what is geographically important, and will confuse the problems with details of value to geologists, botanists, and historians, rather than to geographers. The results of such a description could not fail to be important, but would be most striking if undertaken by a group of professed geographers whose views were in general accord. A national monument might be raised—a work of art as well as science—in the place of a miscellaneous heap of scientific bricks. Nothing would give me greater satisfaction than to see Dr. Mill carrying out his idea in connection with such a group of helpers. H. J. Mackinder.

To the Editors of Knowledge.

Sirs,—I cannot, I regret to say, give "Geographer" the name of any work based exactly on the plan proposed in my article in your January number. The idea suggested is, I believe, a novel one, and an opportunity will be afforded at an afternoon meeting of the Royal Geographical Society, on March 6th, to discuss the possibility of carrying it into effect. The suggestion is simply that each sheet of the one-inch Ordnance Survey map should be provided with a concise memoir or handbook giving a complete index of place-names, the calculation of various physical constants, and a discussion of the geography of the district in the light not of the topographical map alone, but of all such supplementary data as are available in the Geological Survey, and the publications of the learned societies which deal in distributions.

There is one work recently published which, on a small scale and in a somewhat different manner, does carry out the geographical description of a part of the United Kingdom in a more complete way than has ever previously been attempted. It is the Royal Scottish Geographical Society's recently published *Atlas of Scotland*, by Mr. J. G. Bartholomew. This epoch-marking work contains a great map of Scotland in forty-five sheets, on the scale of two miles to one inch, showing contour lines of elevation and sea-depth, appropriately coloured so as to give a vivid idea of the vertical relief of the country. But there is in addition a series of small-scale maps showing the general configuration, the river basins, the distribution of vegetation or agriculture, the distribution of population as to density and as to language, the rainfall for each month and the temperature for each month of the year, the geological structure (on a large scale), the distribution of indigenous animals, the limits of deer-forests and fishery districts, and finally the counties. This is a scientific work the value of which to the student of geography it would be difficult to over-estimate. Were it accompanied by descriptive letterpress instead of mere statistics (the introduction, dealing with the physical features of Scotland, by Prof. James Geikie, is an exception), it would be quite such a work as "Geographer" asks for—a unification through geography of all the sciences involving distributions. Hugh Robert Mill.

1, Savile Row, W.
February, 1896.

Notices of Books.

Justus von Liebig: his Life and Work (1803-1873). By W. A. Shenstone, F.I.C. (The Century Science Series, Cassell & Co.) 3s. 6d. Within a compass of about 200 pages Mr. Shenstone has succeeded in drawing such a vivid picture of Liebig as to enable us to form a clear conception both of the man himself in all his many-sidedness, and of the work in the various fields of pure and applied chemistry to which he devoted himself. Although but twenty-two years have passed since Liebig died, it is to be feared that to the majority of people—at least of the younger generation—he is now little more than a name. And yet he was not merely one of the very greatest chemists that ever lived (and will rank as such for all time), but no other man has ever equalled him either as a teacher of chemistry or in the application of that science to the arts and the various purposes of daily life. After a brief but interesting account of Liebig as a boy and youth, the friendship with his famous collaborator, Wöhler, is well described. This brings us to what we think is the weak point of the memoir, viz., the small space which is allotted to Liebig's discoveries in pure chemistry. The author himself alludes to this in his preface, but at the same time justifies the scale of treatment adopted by saying that "it is right that it should be so, for, vast as were Liebig's services to pure chemistry, they lack in some degree the splendour of his contributions to some other departments of equal intrinsic importance and of far wider general interest." But here we would join issue with him, because not only is much of Liebig's purely chemical work classical, but—what is more—it formed the groundwork to his own investigations in physiological and agricultural chemistry, and also served as a pattern and example to numberless other workers in the science. We trust, therefore, that in the next edition, which will doubtless be called for soon, Mr. Shenstone may see his way to modify his opinion upon this point in some degree, and treat the section in rather more detail. The chapter dealing with Liebig's work in agricultural chemistry is excellent. As a teacher Liebig was unique. Throughout the book, and in the last chapter more especially, justice is done to Liebig's high character and to the great personal influence which he exercised, while we are shown at the same time how intensely human the man was. Space will not admit of our adding anything about the marvellous amount of literary chemical work—scientific and popular—which he also accomplished, or, indeed, of saying more than to advise every student of chemistry, and everyone who is at all interested in the application of chemistry to common life, to read the book.

A Handbook of British Lepidoptera. By Edward Meyrick, B.A., F.Z.S., F.G.S. (Macmillan.) Illustrated. 10s. 6d. This book fills an undoubted want in entomological literature. Several popular books on butterflies and moths have lately been issued, but until now no complete work on British *lepidoptera* has appeared since Stainton's manual, published thirty-six years ago. In an able introduction, Mr. Meyrick explains structural formations, classification, and nomenclature, and thus makes intelligible the descriptions of the insects which follow. From these the collector should be enabled to identify his specimens with accuracy, and also to learn a great deal of their structure, the description of which the author has in every instance drawn up from his own observations. Some entomologists will, no doubt, find fault with Mr. Meyrick's system of classification, but his book will prove invaluable as the outcome of original research.

British and European Butterflies and Moths. By A. W. Kappel, F.L.S., F.E.S., and W. Egmont Kirby, L.S.A. (Nister.) Coloured plates. 25s. This is an excellent popular guide to the *macrolepidoptera* of Europe. Most of the species are included in the volume, and all the British species have English names assigned to them—a feature which has been neglected in many books of recent date. The larva, perfect insect, food plant, time of appearance, and locality of each species is carefully described, while

coloured figures are given of a very large number of insects, larvæ and pupæ. These figures are beautifully executed, and with very few exceptions are wonderfully true to nature. With their help a novice could not fail to identify any species which is figured. We would heartily recommend the book to collectors as the most accurately illustrated one on the subject which we have seen.

Elements of Modern Chemistry. By C. Adolphe Wurtz. Translated by Drs. Greene and Keller. Fifth Edition. (Lippincott Co., Philadelphia.) Medium-sized handbooks on general chemistry are multiplying. Many of these new text-books are simply old ones in a new guise. In the majority of these books the theoretical portion of the science is much neglected, so that they become mere summaries of facts and reactions, without making any real progress in their educational value. We are, therefore, better pleased when we find authors content to bring out a new edition of such a standard work as Wurtz's "Elements of Modern Chemistry," which has already done such good service in the past. Its chief aim is to make clear the inner meaning of chemical laws and phenomena, so that one may confidently assert that theory is the strong point in this text-book. Wurtz is by no means an innovator in theoretical chemistry, but he has the very rare gift of expounding his subject in so easy and brilliant a way as to render chemical theories attractive even for those to whom they are still a terror. The present edition has been considerably enlarged by the translators, and we note that argon and helium are already included among the list of known terrestrial elements. The book is especially adapted for the use of medical students, to whom it will give a sound general knowledge of the elements of chemistry, without wearying them with details of secondary importance.

The Wild Fowl and Sea Fowl of Great Britain. By A Son of the Marshes. Edited by J. A. Owen. (Chapman and Hall.) Illustrated. 14s. In this book the author fully bears out his well-known character as a true and observant field naturalist, but, like the decoy man he describes, he is none too free with his information. The book is full of entertaining anecdotes, but we feel sure that it would have been more widely read had the author omitted the minute descriptions (which may be found in any handbook of British birds), and inserted in their stead more of his delightful local touches of man, bird, and beast. As a guide to the wild fowl and sea fowl of Great Britain the book has no particular interest, but as a fascinating book to read it must appeal to everyone, and, above all, to the field naturalist.

Reader's Shakespeare. Vol. I., Historical Plays. David Charles Bell. (Hodder & Stoughton, 1895.) There are, perhaps, few things so neglected by the average Englishman as the art of elocution. This is partly due to the lack of literature on the subject, and Mr. Bell's volume is not altogether an unsuccessful item towards filling up the gap. For although the author scarcely attempts to deal with the "power of speech" in general, the volume before us—the first of a series—may no doubt tend towards the elocutionary study of Shakespeare. And therefore we would recommend its condensed plays and its accentuated lines to the embryo student, or to the man too busy to make his own selections from the great dramatist.

Biological Lectures. (Ginn & Co.) The thirteen lectures contained in this volume were delivered at the Marine Biological Laboratory of Wood's Holl in the summer session of 1894. Nearly every lecture deals with one or other sides of the problem of organic development, and of the value of the whole to all who are concerned with the question of the nature of life there can be but one opinion. A special feature of the meetings at Wood's Holl is that an endeavour is made to bring the thoughts of workers in physical science to bear upon biological matters. Accordingly, we find that the first lecture in the volume deals with life from a physical standpoint, the expositor being Prof. A. E. Dolbear. This lecture alone is sufficient to form the basis of a review; it aims at showing that phenomena which are held to demonstrate the existence of a vital force may also be exhibited by inorganic matter—that, in fact, a definition of life which cannot be applied to the phenomena of non-living things has not yet been obtained. We look at the beautifully symmetrical arrangement of crystals in a snowflake, and ascribe the structure to physical agencies, denying to it the vital force which is assumed to control the movements of an amœba. Even spontaneous movement is not peculiar to living matter, for Quincke and Bütschli have made artificial protoplasm possessing all the characteristics of amœbæ, by means of a mixture of potassium carbonate and olein oil; which facts result in a feeling among biologists that "the phenomena exhibited by a living thing are finally resolvable into physical and chemical processes." We have only referred to one of the many lectures in the volume, but the others are no less interesting. The volume is not written so that he who runs may read its pages: it is for those who are in the current of modern scientific thought, or who wish to know what are the burning questions with biologists of to-day, and to such we heartily commend it.

Molecules and the Molecular Theory of Matter. By A. D. Risteen, S.B. (Ginn & Co.) Illustrated. 8s. 6d. In this volume the elements of the molecular theory of matter as it is held to-day are elucidated. For many years it has been maintained that every substance, however uniform and homogeneous and quiescent it may appear, is composed of separate particles, each of which is in rapid motion. The author brings together the observations of physicists which go to establish this proposition. Beginning with an examination of the kinetic theory of gases, he shows that a large range of phenomena can be referred to it, and then passes to apply the molecular theory to liquids and gases. The methods by which the general order of magnitude of molecules have been determined are afterwards described. In the last section of the book the field of observation is left, and speculations as to the constitution of molecules and the nature of intermolecular forces are dealt with. This brief statement will show the scope of the work, and it only remains for us to say that the treatment is excellent. A knowledge of mathematics is required before a few of the points discussed can be understood; but a large portion of the book can be readily followed and enjoyed by most readers of scientific literature. Every student of physics should add the volume to his library.

Great Astronomers. By Sir Robert S. Ball, D.Sc., F.R.S. (Isbister & Co.) Illustrated. 7s. 6d. No writer or lecturer on astronomy is better able to entertain the public than Sir Robert Ball. His style is attractive, and often ornate, and he does not over-burden his listener or reader with facts. This book is representative of his manner of exegesis; nothing in it is beyond the comprehension of the general reader, but, at the same time, the treatment is too redundant to be admirable. Too many anecdotes are introduced, on account more of their entertaining character than of their suitability; and the only reason one can imagine for the insertion of some of the information in a volume on "Great Astronomers" is that Sir Robert found the material available, and thereupon determined that its goodness should not be wasted. Having said so much—more in sorrow for the author's irrepressible humour and

diffusibility than in anger at the inadequate accounts he gives of the work of some of the old astronomers—our depreciation ceases. The book is not for the serious student of astronomical history, but for those who read astronomy *pour passer le temps*. It contains an abundance of chatty information concerning the characters and surroundings of many famous astronomers, those whose lives are sketched being Ptolemy, Copernicus, Tycho Brahe, Galileo, Kepler, Newton, Flamsteed, Halley, Bradley, the two Herschels, Laplace, Brinkley, the Earl of Rosse, Airy, Hamilton, Le Verrier, and Adams. Numerous illustrations of these astronomers and their observatories adorn the pages of the book and add to its interest.

Dynamics. By Prof. P. G. Tait, Sec. R.S.E. (A. & C. Black.) 7s. 6d. It is generally easy to recognize the products of a master-mind, and even if this work had been published without the author's name upon the title-page the originality and force of the contents would at once command attention. Only a worker in the foremost ranks of physicists could expound the science of matter and motion in the manner of this volume. In the main the volume is a reprint of the article, "Mechanics," contributed by Prof. Tait to the "Encyclopædia Britannica;" but parts dealing with attraction, hydrostatics, hydrokinetics, etc., have been added to the original to complete the structure of the work. Those who know Thomson (now Lord Kelvin) and Tait's "Treatise on Natural Philosophy" will have an idea of the character of the present volume. Only students of mathematical mind can fully appreciate the force of the reasoning and the fundamental nature of the problems and theorems considered herein; but they will admire the development of the arguments as much as a poetic naturalist does the opening of a flower. A work by Prof. Tait needs no commendation to such students; all we need say to them is that the author's well-known views concerning the misuse of the word "force" find expression in a few sections.

The Natural History of "Eristalis Tenax," or the Drone-fly. By G. B. Buckton, F.R.S. (Macmillan & Co.) Illustrated. 5s. The author gives a description of the habits and anatomy of the drone-fly which will be serviceable to young entomologists, and may result in increased attention being given to the genus to which it belongs. The essay is almost entirely confined to the natural history of *Eristalis tenax* and *E. arbustorum*—both common in many parts of England. The classification, life-history, morphology, physiology, histology, and development, distribution, and myths connected with *Eristalis* are described in separate sections, and the whole is elucidated by nine plates. Entomologists will be glad to have this handy account of an interesting insect.

Pan-Gnosticism. By Noel Winter. (The Transatlantic Publishing Co.) Upon a train of reasoning which we cannot attempt to analyse, the author establishes the theory that completeness of knowledge is attainable, and he names his doctrine "Pan-Gnosticism." The aims of the book are thus very high, and though to us many portions read like tiresome platitudes, probably there are abstract philosophers who will derive satisfaction from an examination of the propositions advanced.

An Analysis of Astronomical Motion. By H. Pratt, M.D. (G. Norman & Son.) Illustrated. Dr. Pratt's theory, so far as we can understand it, is that the sun we see is in revolution around another sun, which in turn revolves around a third sun, and this travels around a fourth body, designated the central sun. Probably no one but the author believes in this quaternary solar system, and we have no desire to deny him the recreation he finds in exercising his ingenuity upon it. The book may be safely left to run its course. Astronomers have only to glance at a few pages to discover the fallacy of the conclusions drawn, and the unnecessary assumptions made to explain simple celestial motions; while readers who are not familiar with the mechanism of the heavens will find the book quite beyond their comprehension.

BOOKS RECEIVED.

A Naturalist in Mid-Africa. By G. F. Scott-Elliot, M.A., F.L.S., F.R.G.S. (Innes & Co.) Illustrated. 16s.

Annual Report of the Board of Regents of the Smithsonian Institution. (Washington: Government Printing Office.)

Evolution and Man's Place in Nature. By H. Calderwood, LL.D., F.R.S.E. (Macmillan.) Illustrated. 10s.

Manual of Lithology. By E. H. Williams. (New York: Wiley & Sons.)

Heating and Ventilating Buildings. By R. C. Carpenter, M.S., C.E. Fifth Edition. (New York: Wiley & Sons.) Illustrated.

The Present Evolution of Man. By G. Archdall Reid. (Chapman & Hall.) 7s. 6d.

Applied Magnetism. By J. A. Kingdon, B.A. (H. Alabaster, Gatehouse, & Co.) Illustrated. 7s. 6d.

By Tangled Paths. By H. Mead Briggs. (Warne & Co.) Illustrated. 3s. 6d.

Minerals, and How to Study Them. By E. S. Dana. (New York: Wiley & Sons.) Illustrated.

Insect Life. By F. V. Theobald, M.A., F.E.S. (Methuen.) Illustrated. 2s. 6d.

Roads and Pavements in France. By A. P. Rockwell. (New York: Wiley & Sons.) Illustrated.

The Journal of Malacology. Vol. IV. (Dulav.) Illustrated. Cloth, 5s. 6d.

Remarkable Comets. By W. T. Lynn, B.A., F.R.A.S. Fourth Edition. (Stanford.) 6d.

Matriculation Directory. (University Correspondence College Press.) 1s.

Annuaire pour l'An 1896. (Brussels: Institut Nationale de Géographie.)

The World's Two Metal and Four Other Currency Intermediaries. By J. H. Norman. (Effingham Wilson.)

Submarine Telegraphy. By J. Bell and S. Wilson. (*Electricity*.) 1s. 6d.

The Influence of Literature on Architecture. By A. T. Bolton, Royal Institute of British Architects.

PROTECTIVE RESEMBLANCE IN BIRDS.

By Harry F. Witherby.

PROTECTIVE resemblance, by whatever form of life it is exemplified, is a well-worn subject; but it is a subject of continual and lasting interest to those who love the beautiful in nature, and it is one of which, if our eyes are opened, we are every day seeing examples.

In the present article it is proposed merely to deal with a few instances of protective resemblance in birds, their nests and eggs, and not to touch on the theories which surround the subject, and which have been so often ably expounded. It is hardly necessary to explain the term "protective resemblance," but to the uninitiated we may say that it is the more or less complete likeness, in colouring or form or both, which a creature or object bears to its surroundings, thus often escaping detection.

In the accompanying full-page plate, which is an enlarged reproduction of a photograph taken by Mr. Geo. Burn Murdoch, of Doune, Perthshire, we have a beautiful example of a living creature so nearly in nature resembling its surroundings that it is difficult even for the practised eye to detect it. In the photograph the outline of the woodcock is, of course, more clearly defined than in nature; but even in the plate it is difficult to distinguish the bird if one stands some distance away. Now this protective colouring is admirably fitted to the needs of the woodcock, both in winter and summer. It is nocturnal in habit, and

WOODCOCK ON ITS NEST AMONGST THE FALLEN LEAVES.

From a Photograph by Mr. George Burn Murdoch.

XUM

spends the day concealed in woods and copses, often under some thick shrub and always on the ground; and the mottled browns and reds of its plumage so nearly resemble the leaves with which the ground in a wood is always covered,

Nest of Little Grebe as left by bird, the eggs covered with weed.

that it is almost impossible to discover the bird even when one is searching for it. Indeed, were it not for its round and lustrous black eye the "cock" would seldom be seen on the ground. In the nesting season its protective colouring is again of the greatest service. The nest is a slight hollow amongst the fallen leaves, often in a sheltered position, as in our illustration, where the bird has ensconsed itself beneath a fallen bough; and here it sits on eggs or young in conscious security, allowing itself to be almost trodden upon before it moves. Few birds are so well protected by their colour as the woodcock, and it is difficult to say why this bird should be so singularly well provided for in this respect; but it may be taken as a general rule that birds (especially the females) which rest or make their nests on the ground are more or less protectively coloured. A striking case of protective resemblance is afforded by the males of many sorts of ducks and geese at certain periods of the year. These birds, as everyone knows, are very gaily attired in comparison to the females, but, strange to say, for several weeks in the summer they lose their brilliantly-coloured plumage and assume the duller garb of the female. On enquiring into the cause of this curious change we find that, contrary to the usual rule, ducks and geese moult all their flight feathers at the same time, and are therefore incapable of flight for a considerable time. When in this helpless state they generally resort to reed beds and such places, and it will be easily seen what an immense advantage the dull and protective plumage is to them at this period.

There are not so many examples of protective resemblance which are easily recognized in birds as in other classes of animal life. The habits of the bird must generally be closely studied in connection with its colouring before it can be ascertained if this colouring is a special protection, and these cases are always of greater interest than those which are more apparent.

Turning from the bird to its nest or eggs, we have abundant examples—especially in those species which build their nests or lay their eggs in positions exposed and easy of access.

What ornithologist has not hunted for hours, and often in vain, for the eggs of some bird such as the ringed plover or tern, which lays its eggs without a nest of any sort amongst the shingle? In fact, the only satisfactory way of finding these eggs is to watch the bird from a distance until it settles on them, and then to walk straight up to the spot. Even then, if the eye is not kept steadily on the mark, one may often walk past or even over the eggs without seeing them, so closely do they resemble the stones amongst which they are laid.

Again, take the familiar examples of the peewit, the goatsucker, and skylark—every countryman must have experienced the difficulty of finding the eggs of these birds. Many birds, too, such as the chaffinch, the long-tailed tit, the wren, and a host of others, make their nests of materials so much akin to those with which they are surrounded that a passing glance would not detect the nest. One is often only conscious of a slight thickening in a bough or of some irregularity of form, until a more careful scrutiny reveals a nest.

Turning now to the two illustrations of the nest of a little grebe or dabchick (also from photographs by Mr. G. Burn Murdoch), we have a curious instance of protective resemblance coupled with a mild deception practised by the owner of the nest. The dabchick lays its eggs on some mass of green floating weed which is so common on streams and ponds. This nest, if we may so call it, is

Same nest as above, with covering over eggs removed.

like any other mass of weeds, except, perhaps, that it is a little higher and more compact, but not sufficiently so to enable one to distinguish it. So far, then, the nest is perfectly safe; but when the bird has laid its chalky white eggs it would be instantly detected had not its owner the

means of concealing them. This it effects by covering up the eggs with weed as it leaves them; thus once more transforming the nest into apparently nothing more than a floating mass of weed. In the one photograph we have the nest as it was left by the bird, while in the other the weed covering the eggs has been removed. This covering of wet, dirty weed answers other purposes, for, in a few days' time, the eggs become so covered with dirt that they are exactly the colour of the nest, and thus stand a chance of escaping detection should the bird be forced to leave the nest before it has time to hide its eggs, as sometimes happens. Moreover, the wet weed, by "heating," serves to keep the eggs warm, thus allowing the bird to leave them for a considerable time if necessary.

We have dealt with but a few examples of protective resemblance, but we venture to think that enough has been said to show what variety and interest is attached to the subject.

THE LIMBS OF TRILOBITES.

By Philip Lake, M.A., F.G.S.

Of all the fossils which are found among the older rocks of the earth's crust, there are none which have attracted more attention than trilobites. Even so long ago as the seventeenth century Lhwyd drew and described certain "figured stones," among which several of these forms may be recognized. The name itself dates from the year 1771, and is derived from the trilobed character of the body.

In spite, however, of the labours of generations of skilled palæontologists, little was known of these animals except the shell or "test" of the back. For it is a remarkable fact that, although trilobites are very common in many localities, yet it is only the back that is seen, and in very few cases indeed has the under-surface of the body been observed, or any trace of limbs. There are several ways of accounting for this. In the first place, the limbs may have been soft and delicate, unfitted for preservation in a fossil condition; and, in the next place, it is pretty certain that trilobites, like most crustaceans, used to cast their shells periodically, and it is probable that many of the specimens we find are simply these discarded coverings.

Within the last few years, however, a great deal of light has been thrown upon the structure of trilobites by the discovery of extraordinarily well preserved specimens near Rome, in the State of New York; and this discovery is so remarkable that it deserves more than a passing notice.

An ordinary trilobite, such as the "Dudley locust" (Fig. 1), so abundant in the limestones near Dudley, is made up of three distinct parts. In front is a semicircular shield-like head, usually bearing a pair of eyes; behind this there are a number of narrow segments articulating with one another, and forming what is called the thorax; and behind the thorax is another broad shield generally spoken of as the tail. We do not know how far the head, thorax, and tail correspond with the similarly named parts of other animals; but the terms will serve if we remember, for example, that the thorax does not exactly represent the thorax of an insect.

Many other crustaceans also possess parts which may be called head, thorax, and tail; but trilobites exhibit several peculiarities which are not met with in other forms. In every trilobite the body is more or less clearly marked out into three divisions by two longitudinal furrows, which run from the head through the thorax into the tail. Between the furrows lies the "axis," which generally forms a prominent ridge extending nearly the whole length of the body; and on each side of the axis are the more flattened "lateral lobes."

The head usually presents another peculiarity which is not found in the adult of any living crustacean. In a form such as *Calymene* it will often happen that even a good specimen does not show the whole of the head, but only the central part. At the same time it will be clear that this is not

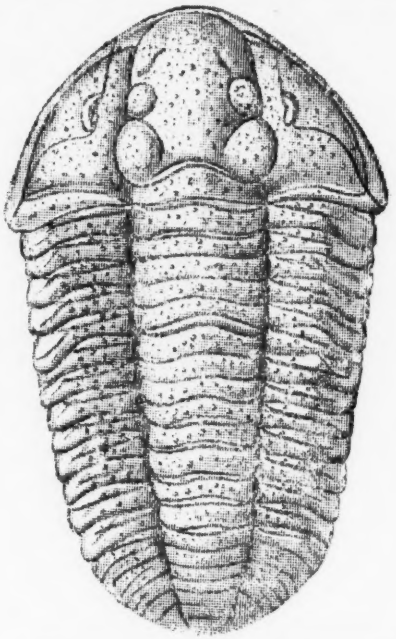


Fig. 1.—*Calymene Blumenbachi* (the "Dudley locust").

due to an accidental fracture, for the separation has taken place along a regular symmetrical line; and if we examine a complete specimen we shall find this line distinctly marked. The head, in fact, is jointed, and the line of the joint separates the lateral parts of the head from the central portion. This line is called the "facial suture," and in *Calymene* it runs from the front margin to the hinder corners of the head.

The trilobation of the body and the presence of the facial suture are the two most striking peculiarities of the upper surface of trilobites. The king-crab of the present day in its young state is distinctly trilobed, and also shows a facial suture, and hence many writers were led to conclude that it is the nearest living ally of the trilobites. But this idea is probably incorrect.

Of the under-surface of the body, the only part that is commonly met with is the "labrum" or "hypostome" (see Figs. 4 and 5). This is a broad plate attached to the front margin of the head and reaching backwards as far as the mouth.

Nearly half a century ago a Russian geologist named Eichwald found certain jointed cylindrical fossil fragments along with numerous trilobites, and he came to the conclusion that these were the antennæ and limbs. But they were not attached to the bodies, and most palæontologists looked upon them with suspicion.

Other writers found what they supposed to be the points of attachment of limbs; but it was not till 1870 that any specimen was discovered showing the limbs actually attached to the body itself. It was in a specimen of the genus *Asaphus* (Fig. 2), in America, that this fortunate

discovery was made; and it showed that each of the eight thoracic segments bore a pair of cylindrical-jointed legs, adapted for walking rather than swimming. About the

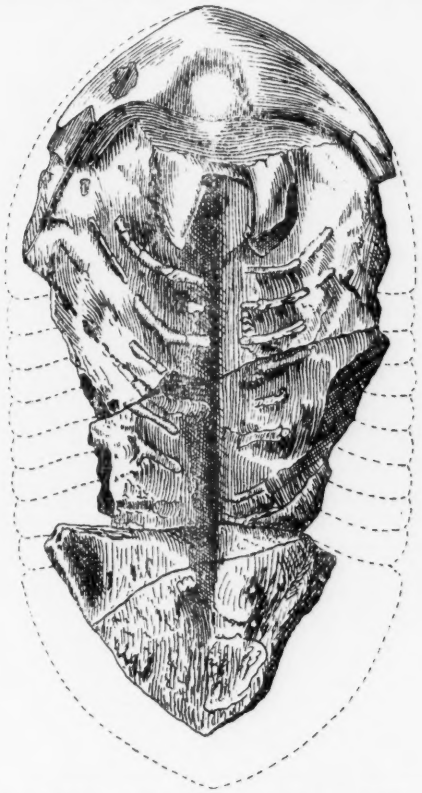


Fig. 2.—Under side of *Asaphus platycephalus*, showing the thoracic legs. (After Billings.)

same time Dr. Woodward discovered a small palp, not unlike the palps of the jaw of an insect, lying close up against the hypostome of another specimen of the same species.

But in spite of such discoveries there were still sceptics who denied that these were really limbs, and looked upon the "legs" as mere thickenings of the under-surface of the body. In order to set this question at rest an American geologist, Walcott, conceived the idea of cutting across the bodies of well-preserved trilobites and thus exposing the limbs in section, if they should happen to have left any traces of their presence. He made several thousands of sections, but only some two hundred and seventy of them were found to be of any use.

Even with these sections it was no easy task to determine the character of the limbs. A single section could show but little; and it was only by examination of the whole series that Walcott was enabled to form a general idea of the nature of the appendages.

He found no trace of antennæ; but the head bore four pairs of appendages surrounding the mouth (Fig. 3). All were jointed, and the first three were slender, while the fourth was much stronger and broader. Each segment of the thorax and of the tail also possessed its own pair of limbs; and these were all of the same character, but diminished in size towards the tail. Each limb (Fig. 4) consisted of a broad basal joint articulating with the body; and from this joint sprang two branches, both of them slender and made up of several segments. The outer branch was provided with a row of bristles. Such limbs could not have been used for swimming, and the animal must have crawled upon the bottom of the sea.

But this is not all. Many of the legs also bore a delicate doubly-branched filament, which was often coiled into a spiral. These, no doubt, were the gills or breathing organs. Many living crustacea have the gills attached to the limbs, and in the genus called *Cyamus* these gills are spiral.

Walcott's observations thus confirmed the conclusions based on the American specimen of *Asaphus* already noticed, and they were themselves confirmed by the discovery of a second specimen (of a slightly different species) showing the limbs much more perfectly (Fig. 5).

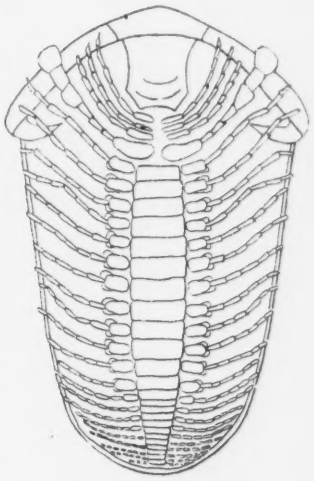


Fig. 3.—Restoration of the under surface of *Calymene*. (After Walcott.)

So matters remained until the last year or two, when a startling discovery was made near Rome, in the State of New York. Trilobites are very abundant in certain slaty beds near that town, and they are more perfectly preserved than any which have hitherto been found elsewhere. Many of the specimens show the limbs, and some of them even possess antennæ, of which no trace had yet been discovered. Most of them belong to the species *Triarthrus becki*, but other forms are not uncommon. The specimens have been partly described by Matthew and Beecher, and the latter is still engaged in studying them.

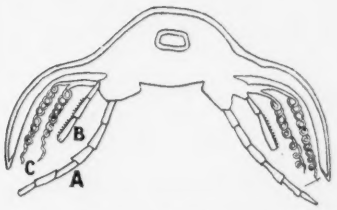


Fig. 4.—Section of *Calymene*. (After Walcott.) A, inner branch of the limb; B, outer branch; C, spiral gills.

The presence of antennæ is, perhaps, the most interesting feature of the discovery (Fig. 6). They are attached to the sides of the hypostome on the under-surface of the head, and extend forwards as slender jointed filaments, not unlike the antennæ of a lobster. Besides these, the head bears four pairs of appendages, as Walcott had concluded. The thorax also and the tail bear limbs, and all of the appendages except the antennæ are built upon the same plan. Each commences with a basal joint articulating with the body of the animal, and from this spring two branches, each of which is made up of a number of joints or segments.

But although the general plan of all the limbs is the same, the details are modified in different parts of the body to suit various purposes. In the head the limbs were required to serve as jaws, while towards the hinder end of the body they were used for swimming. We may look upon the appendages of the second thoracic segment as a kind of middle stage between these extremes. The inner part

of the basal joint is here prolonged into a spur projecting towards the middle line of the body; the two branches are long and slender, and the outer one bears a row of bristles.

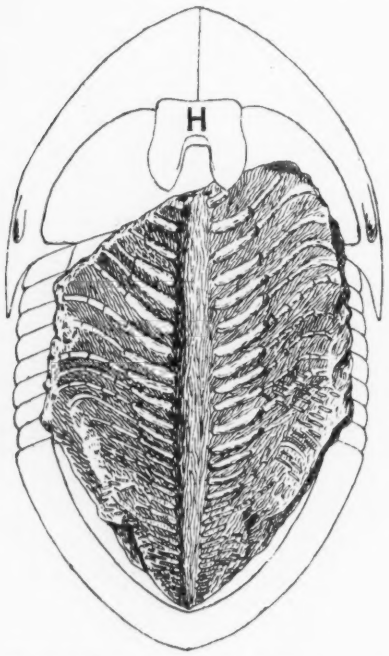


Fig. 5.—Under surface of a specimen of *Asaphus megistos*, showing the limbs. (After Walcott.) H, hypostome.

In the head (Fig. 6) the basal joint is more strongly developed, and the spur is modified to form a jaw working against the corresponding part of the limb on the other side of the body. At the same time the two branches of the limb become smaller and weaker.

As we trace the limbs backwards, on the other hand, we find that the spur of the basal joint becomes shorter; and the segments of the inner branch, instead of remaining cylindrical, become broad and flat. The whole limb, in fact, is adapted for swimming rather than for any other purpose.

Hitherto no trace of the spiral gills described by Walcott has been discovered in these specimens. But it must be remembered that Walcott's sections belonged to quite a different genus of trilobites. Allowing for this and for the great difficulties with which he had to contend, it is gratifying to find that his careful and painstaking researches led him so nearly to the truth. There can be little doubt that the genera examined by him (*Calymene* and *Ceraurus*) bore antennæ, although he did not discover them. Indeed, Walcott himself now believes that he has found a trace of antennæ in some of his sections. It is probable, too, that the appendages of the tail of *Calymene* may have been flattened, but this must remain doubtful for the present.

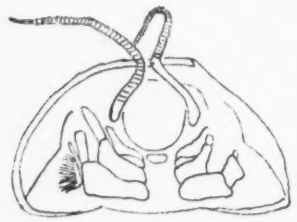


Fig. 6.—Under side of head of *Triarthrus*, showing the antennæ and organs of the mouth. (After Beecher.)

We may heartily congratulate the American palæontologists upon the results of their long-continued labours; but is it too much to hope that Europe may some day join in these researches? Not a single specimen of a trilobite showing appendages has yet been discovered except in America. Surely a diligent search among the least altered of our older rocks might meet with its reward.

THE FACE OF THE SKY FOR MARCH.

By Herbert Sadler, F.R.A.S.

SUNSPOTS and faculæ are evidently decreasing in number and size, but should be observed whenever the Sun is visible. Conveniently observable minima of Algol occur at 9h. 56m. P.M. on the **20th** and at 6h. 45m. P.M. on the **23rd.**

Mercury is a morning star, but, in spite of his attaining his greatest western elongation (27¼°) on the **5th**, he rises so soon before the Sun that he is by no means well situated for observation. We give an ephemeris of him for the first third of the month; after that he approaches the Sun too closely to be visible. On the **1st** he rises at 5h. 51m. A.M., or about one hour before the Sun, with a southern declination of 16° 12′, and an apparent diameter of 7½″, just one-half of the disc being illuminated. On the **6th** he rises at 5h. 47m. A.M., or 50m. before the Sun, with a southern declination of 15° 31′, and an apparent diameter of 7″, $\frac{58}{100}$ths of the disc being illuminated. On the **11th** he rises at 5h. 44m. A.M., or 41m. before the Sun, with a southern declination of 14° 14′, and an apparent diameter of 6½″, $\frac{65}{100}$ths of the disc being illuminated. While visible he describes a direct path in Capricornus to the borders of Aquarius.

Venus is a morning star, but is rapidly getting lost in the Sun's rays. In her case, also, we only give an ephemeris for the first third of the month. On the **1st** she rises at 5h. 38m. A.M., or 1h. 10m. before the Sun, with a southern declination of 18° 4′, and an apparent diameter of 12¾″, $\frac{83}{100}$ths of the disc being illuminated. On the **11th** she rises at 5h. 30m. A.M., or 55m. before the Sun, with a southern declination of 14° 54′, and an apparent diameter of 12¼″, $\frac{86}{100}$ths of the disc being illuminated. While visible she describes a direct path in Capricornus, being near ϑ Capricorni on the **3rd.**

Mars is at present an object of no interest whatever to the amateur, and Uranus rises so late that we defer an ephemeris of him until next month.

Jupiter is still a splendid object, both in the evening and morning sky. On the **1st** he sets at 5h. 32m., or 1h. 16m. before sunrise, with a northern declination of 20° 52′, and an apparent equatorial diameter of 44·4″. On the **11th** he rises at 0h. 47m. P.M., with a northern declination of 21° 0′, and an apparent equatorial diameter of 43¼″. On the **21st** he sets at 4h. 10m. A.M., or 1h. 51m. before sunrise, with a northern declination of 21° 3′, and an apparent equatorial diameter of 42·0″. On the **30th** he rises at 11h. 30m. A.M., and sets at 3h. 31m. A.M. on the **31st**, with a northern declination of 21° 2′, and an apparent equatorial diameter of 40¾″. He describes a short retrograde path in Cancer till the **21st**, when he begins to retrace his steps. The following phenomena of the satellites occur before midnight on the days named, while the planet is more than 8° above and the Sun 8° below the horizon: On the **1st** a transit ingress of the third satellite at 6h. 49m. P.M., of its shadow at 10h. 13m. P.M.; a transit egress of the satellite itself at 10h. 27m. P.M., an occultation disappearance of the first satellite at 11h. 26m. P.M. On the **2nd** a transit egress of the fourth satellite at

6h. 34m. P.M., a transit ingress of the first satellite at 8h. 45m. P.M., of its shadow at 9h. 37m. P.M., a transit ingress of the shadow of the fourth satellite at 10h. 1m. P.M., a transit egress of the satellite at 11h. 5m. P.M., a transit egress of the shadow of the first satellite at 11h. 57m. P.M. On the **3rd** an eclipse reappearance of the first satellite at 9h. 3m. 17s. P.M. On the **7th** a transit ingress of the second satellite at 7h. 38m. P.M., of its shadow at 10h. 32m. P.M., a transit egress of the satellite at 10h. 19m. P.M. On the **9th** an eclipse reappearance of the second satellite at 7h. 27m. 32s. P.M., a transit ingress of the shadow of the first satellite at 10h. 33m. P.M., and of its shadow at 11h. 31m. P.M. On the **10th** an occultation disappearance of the fourth satellite at 10h. 16m. P.M., and an eclipse reappearance of the first satellite at 10h. 58m. 26s. P.M. On the **11th** a transit egress of the first satellite at 7h. 20m. P.M., and of its shadow at 8h. 20m. P.M. On the **12th** an eclipse reappearance of the third satellite at 7h. 41m. 57s. P.M. On the **14th** a transit ingress of the third satellite at 10h. 2m. P.M. On the **16th** an eclipse reappearance of the second satellite at 10h. 2m. 46s. P.M. On the **17th** an occultation disappearance of the first satellite at 9h. 31m. P.M. On the **18th** a transit ingress of the shadow of the first satellite at 7h. 55m. P.M., a transit egress of the satellite at 9h. 9m. P.M., a transit egress of its shadow at 10h. 15m. P.M. On the **19th** an occultation reappearance of the third satellite at 7h. 15m. P.M., an eclipse reappearance of the first satellite at 7h. 22m. 31s. P.M., an eclipse disappearance of the third satellite at 8h. 9m. 38s. P.M., a transit egress of the shadow of the fourth satellite at 8h. 48m. P.M., an eclipse reappearance of the third satellite at 11h. 41m. 42s. P.M. On the **23rd** an occultation disappearance of the second satellite at 7h. 28m. P.M. On the **24th** an occultation disappearance of the first satellite at 11h. 21m. P.M. On the **25th** a transit ingress of the first satellite at 8h. 40m. P.M., of its shadow at 9h. 50m. P.M., a transit egress of the satellite at 11h. 0m. P.M. On the **26th** an occultation disappearance of the third satellite at 7h. 19m. P.M., an eclipse reappearance of the third satellite at 12h. 9m. 8s. P.M. On the **30th** an occultation disappearance of the second satellite at 9h. 57m. P.M.

Saturn is an evening star, rising on the **1st** at 11h. 43m. P.M., with a southern declination of 15° 10′, and an apparent equatorial diameter of 9·1″ (the major axis of the ring system being 42·0″ in diameter, and the minor $15\frac{1}{2}''$). On the **10th** he rises at 11h. 8m. P.M., with a southern declination of 15° 6′, and an apparent equatorial diameter of 9·2″ (the major axis of the ring system being $42\frac{1}{2}''$ in diameter, and the minor $15\frac{3}{4}''$). On the **20th** he rises at 10h. 26m. P.M., with a southern declination of 14° 59′, and an apparent equatorial diameter of 9·4″ (the major axis of the system being 43″ in diameter, and the minor 16″). On the **31st** he rises at 9h. 41m. P.M., with a southern declination of 14° 50′, and an apparent equatorial diameter of $9\frac{1}{2}''$ (the major axis of the ring system being $43\frac{1}{2}''$ in diameter, and the minor $6\frac{1}{4}''$). Titan is at his greatest eastern elongation at 2h. A.M. on the **16th**, and Iapetus at superior conjunction at 4h. A.M. on the **7th**. During March Saturn describes a short retrograde path in Libra, without approaching any naked-eye star.

Neptune is an evening star, but should be looked for as soon as possible after sunset. He is in quadrature with the Sun on the **5th**. On the **1st** he rises at 10h. 14m. A.M., with a northern declination of 21° 13′, and an apparent diameter of 2·6″. On the **31st** he sets at 0h. 25m. A.M., with a northern declination of 21° 17′. During March he describes a very short direct path in Taurus, to the south of the $4\frac{3}{4}$ magnitude star ι Tauri. At 7h. P.M. on the **10th** he is in conjunction with ι Tauri, 13′ to the south, and about 8h. P.M. on the **31st** he is in conjunction with the $6\frac{1}{2}$ magnitude star B.A.C. 1555, $8\frac{1}{3}'$ to the north. A map of the small stars near his path will be found in the *English Mechanic* for August 16th, 1895.

There are no very well marked showers of shooting stars in March.

The Moon enters her last quarter at 11h. 29m. A.M. on the **6th**; is new at 10h. 48m. A.M. on the **14th**; enters her first quarter at 11h. 57m. A.M. on the **22nd**; and is full at 5h. 21m. A.M. on the **29th**. She is in apogee at 1h. A.M. on the **15th** (distance from the Earth, 252,620 miles), and in perigee at midnight on the **28th** (distance from the Earth, 221,670 miles).

Chess Column.

By C. D. LOCOCK, B.A.Oxon.

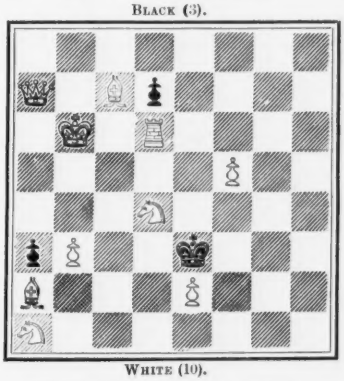
Communications for this column should be addressed to C. D. LOCOCK, Burwash, Sussex, and posted on or before the 12th of each month.

PROBLEMS.

No. 1.

By J. T. Blakemore.

BLACK (3).



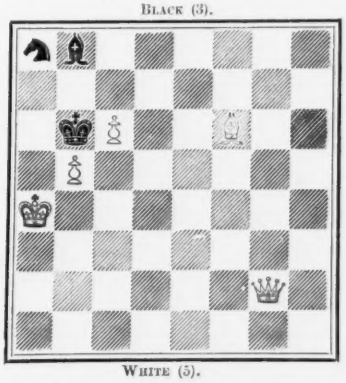
WHITE (10).

White mates in three moves.

No. 2.

By C. D. Locock.

BLACK (3).



WHITE (5).

White mates in two moves.

A. Firth.—Many thanks for the report.

A Norseman.—Thanks for your note and the formula; we have not found time to examine it yet.

The following was, perhaps, the finest game played in the recent tournament at St. Petersburg.

"Queen's Gambit Declined."

White. (H. N. Pillsbury.)	Black. (E. Lasker.)
1. P to Q4	1. P to Q4
2. P to QB4	2. P to K3
3. QKt to B3	3. KKt to B3
4. Kt to B3	4. P to B4
5. B to Kt5	5. P × QP
6. Q × P	6. Kt to B3
7. Q to KR4	7. B to K2
8. Castles	8. Q to R4
9. P to K3	9. B to Q2
10. K to Ktsq	10. P to KR3
11. P × P	11. P × P
12. Kt to Q4	12. Castles
13. B × Kt	13. B × B
14. Q to R5	14. Kt × Kt
15. P × Kt	15. B to K3
16. P to B4	16. QR to Bsq
17. P to B5	17. R × Kt
18. P × B	18. R to QR6
19. P × Pch	19. R × P
20. P × R	20. Q to Kt3ch
21. B to Kt5	21. Q × Bch
22. K to Rsq	22. R to B2
23. R to Q2	23. R to B5
24. KR to Qsq	24. R to B6
25. Q to B5	25. Q to B5
26. K to Kt2	26. R × P
27. Q to K6ch	27. K to R2
28. K × R	28. Q to B6ch
29. K to R4	29. P to Kt4ch
30. K × P	30. Q to B5ch
31. Resigns	

CHESS INTELLIGENCE.

The important quadrangular tournament at St. Petersburg resulted as follows:—

First Prize	... E. Lasker	...	11½
Second Prize	... W. Steinitz	...	9½
Third Prize	... H. N. Pillsbury	...	8
Fourth Prize	... M. Tchigorin	...	7

Each player played six games with every other, so that the highest possible score was eighteen. As might have been expected in such a tournament, or, rather, series of matches, none of the competitors approached this ideal score.

The final result is more or less in accordance with established form. Lasker was last year the acknowledged champion of the world, in succession to Steinitz, who had held the post for nearly thirty years. Pillsbury was the new star which had eclipsed all others at Hastings; while Tchigorin, though a very fine player, had never, to our knowledge, won outright any tournament or match of primary importance. In spite of this, all sorts of excuses have been made for his position on the list. One of the four had of necessity to occupy the lowest place. Tchigorin, who had whatever advantage there is in playing in his native land, came out a good fourth, with a by no means discreditable score. It is true that he made more oversights than usual, but Steinitz and Pillsbury were almost equally unfortunate in this respect.

Pillsbury's play is to a certain extent unaccountable. At the conclusion of the first half of the tournament he actually held the lead; in the second half he did not win a single game. This breakdown does seem to require some explanation. Such, however, is not forthcoming, even from the player himself. It is noteworthy, especially, that he did not win a single game from Steinitz.

The last-mentioned player was a little fortunate in this and in some other respects. His position is most creditable, but he owes it entirely to his success against Pillsbury. He won two games from Tchigorin, and one from Lasker.

Lasker, as will be seen from the score, won with comparative ease. No doubt he could, if necessary, have added another half point or so to his score; but with victory certain he may well have been content to draw his last two games without running any risks or incurring any unnecessary fatigue. Certainly he has more than atoned for his comparative failure at Hastings, where, like Tarrasch and Steinitz, he was handicapped by ill-health. Though beaten by Pillsbury in their individual encounters, he would have been equal to him if he had played his first game in anything like his proper form.

The following is an analysis of the score:—

Lasker beat Steinitz (3½ to 1½) and Tchigorin (5 to 1).

Steinitz beat Pillsbury (5 to 1).

Pillsbury beat Lasker (3½ to 2½) and Tchigorin (3½ to 2½).

Tchigorin beat Steinitz (3½ to 2½).

Matches and rumours of matches have arisen from this great contest. Steinitz will play a match of twelve games with Schiffers at Kharkoff. The latter player should hardly do more than offer a sturdy resistance. The committee of the Hastings Club have offered £150 for a championship match between Lasker and Steinitz, to be played in that town next May, only to find that the Moscow Club had already been in negotiation for a similar contest at the same date, and under conditions more likely, it is said, to be satisfactory to the two parties concerned.

The present score in the Vienna Chess Club Tournament is:—Englisch 7½, Marco 6½, Schlechter 6, Schwarz 5½, Tinkl 5½, Weiss, Albin, Max Judd, and Halprin 4½, Mandelbaum 4.

Contents of No. 124.

	Page
Some Curious Facts in Plant Distribution. By W. Botting Hemsley, F.R.S.	25
Waves.—II. The Waves of the Sea Shore. By Vaughan Cornish, M.Sc. (*Illustrated*)	26
Antarctic Exploration. By William Bruce	28
Notices of Books. (*Illustrated*)	31
Letters:— W. H. Monck; Geographer	34
Greek Vases.—I. Introductory. By H. B. Walters, M.A., F.S.A. (*Illustrated*)	36
What is a Nebula? By E. Walter Maunder, F.R.A.S.	38
Nebula near 15 Monocerotis. By Isaac Roberts, D.Sc., F.R.S.	39
Comets of Short Period. By W. E. Plummer, M.A., F.R.A.S.	40
The Spanish Chestnut. By George Paxton. (*Illustrated*)	43
Life in Babylonia in Patriarchal Times. By Theo. G. Pinches, M.R.A.S. (*Illustrated*)	44
Science Notes	46
The Face of the Sky for February. By Herbert Sadler, F.R.A.S.	47
Chess Column. By C. D. Locock, B.A.Oxon.	47

Two Plates.—1, The Breakwater at Colombo during the S.W. Monsoon. 2, Photograph of the Nebula near 15 Monocerotis.

NOTICES.

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